
SOILS-VEGETATION-LANDFORMS
OF THE WRIGLEY AREA, N.W.T.

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by

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The data for this report were obtained as a result of investigations carried out under the Environmental-Social Program, Northern Pipelines, of the Task Force on Northern Oil Development, Government of Canada. While the studies and investigations were initiated to provide information necessary for the assessment of pipeline proposals, the knowledge gained is equally useful in planning and assessing highways and other development projects.

The research was carried out and the report was prepared under contract for the Arctic Land Use Research Program, Northern Natural Resources and Environment Branch, Department of Indian Affairs and Northern Development. The views, conclusions and recommendations expressed herein are those of the author and not necessarily those of the Department.

FOREWORD

This report by the Department of Soil Science, University of British Columbia, under the aegis of the Arctic Land Use Research (ALUR) program, Department of Indian and Northern Affairs, is a contribution toward the concept of environmental quality through an understanding of scientific land use.

Our program was carried out in cooperation with Dr. N.W. Rutter, Geological Survey of Canada, and his colleagues to whom we express our sincere appreciation for their co-operation and collaboration.

Sincere thanks are extended to our colleagues at the University for their assistance and especially to B. Loughran who drafted the figures and maps.

The views, conclusions and recommendations expressed herein are those of the authors and not necessarily those of the Department of Indian and Northern Affairs.

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1. SUMMARY

Information and assessment of physical environmental parameters, that is geologic materials, soils, vegetation and landforms, are presented here to improve understanding of environmental conditions in the Wrigley area, Northwest Territories. The area studied is an east-west strip of land, north of Wrigley, from which results can be extrapolated to adjacent areas. The information presented will, it is hoped, aid in the extrapolation of site-specific research and of more general, integrated environmental factors to the broader context described by the Geological Survey of Canada. We hope that such research will foster cooperative studies of environmental classification and terrain sensitivity as applied to defining land use objectives and more specifically to the design, construction and maintenance of pipelines in the Mackenzie Valley corridor.

The program evolved around an environmental inventory of surficial geology, landforms, soils and vegetation. Laboratory analyses and site-specific studies on the inter-relationships of these factors were conducted to develop an assessment of the physical environment and the prediction of possible land use disturbance.

The major problems identified with regard to pipeline construction are associated with extensive areas of poorly-drained mineral and organic soils with variable amounts of ice content;

large areas of silty and clayey soils of high ice content potential; general lack of construction aggregate within this portion of the Mackenzie Valley and the general lack of long duration information in this area of discontinuous permafrost.

Recommendations regarding these factors as well as other environmental considerations are given.

2. INTRODUCTION

The 1972 program was carried out at the request of the Department of Indian and Northern Affairs under the Arctic Land Use Research (ALUR) program. The scope of the study was to aid in understanding the land resources of the area in the light of conservation and environmental quality and likely pipeline or other transporation needs. It was oriented to the collection and evaluation of information on physical environmental factors which should be utilized in the planning, design, construction and maintenance of all land use operations within the area.

The research reported here supplements more general terrain reconnaissance surveys being undertaken by the Geological Survey of Canada and will assist the development of a terrain classification system and a terrain sensitivity index. The study area was near Wrigley, N.W.T. and, at the direction of Dr. N.W. Rutter, G.S.C., a strip of land running east to west north of Wrigley was studied. The strip is representative of large areas along this section of the Mackenzie River Valley as it includes both mountainous and level terrain with their associated diversity of landscape features.

The specific objectives of the study were as follows:

(a) preliminary classification of selected areas based on air photographic interpretation,

(b) field checking for ground truth of the physical environmental parameters with particular reference to characterization of organic terrain and permafrost conditions, and

(c) land inventory and assessment of the selected area involving appraisal of vegetation, soils and landform relationships.

3. RESUME OF CURRENT STATE OF KNOWLEDGE

Despite the alleged lack of environmental understanding in Northern Canada, there is an appreciable body of information about the Boreal region. Much of this information however is indirect as it must be extrapolated from areas outside the Mackenzie Valley. A recent annotated bibliography (Roberts-Pichette, 1972) lists 487 references of value for northern studies. In addition, the G.S.C.'s current mapping programs of surficial geology, river bank stability and terrain sensitivity are contributing a large amount of relevant data.

Within the Boreal Forest Region of Canada's North, an area characterized by intermittent permafrost, fewer relevant studies have been conducted on environmental problems than either in the permafrost areas or in permafrost-free areas further south. Most studies in this area have been of an inventory type. There have been few long-term studies to elucidate seasonal or cyclic changes, and little attention paid to the dynamics of change. Limited data are available for example on ground frost dynamics, on vegetation succession following forest fires, the influence of soil type and vegetative cover on permafrost, the drainage and properties of large areas of organic terrain, the break-up of ice on rivers and so on.

The landscape in the Fort Simpson-Wrigley areas of the NWT is a vegetation mosaic resulting from repeated forest fires. The effect of forest fires on the removal of insulation from the soil surface and on the vegetative successsion has been studied in only a few isolated areas. The re-vegetation of disturbed sites and the interaction of forest fires and wildlife habitat have received little attention here. The geology and the soils in the area, except for surficial geology, have been only partly documented (Day 1968). Climatological information especially as it affects vegetation, ground ice, river ice and soil erosion is lacking.

In general, studies are required that entail more continuous observations of environemntal factors within the area. They should include not only standard long-term site studies but also the application of various kinds of remote sensing, including conventional air photographs, which should be interpreted sequentially through time and integrated with site-specific studies. For example, knowledge of soil conditions and recognition of vegetation types from conventional air photographs can help in estimating the depth to permafrost. Hopkins et al (1965) in Alaska indicated that depth to permafrost varied from a minimum of 30 cm. under black spruce in muskeg to 2.5 m. on adjacent floodplains.

Thus a more complete characterization of distribution, depth and dynamics of the sporadic permafrost and the ability to predict its occurrence by remote techniques is a desirable prerequisite for land use considerations in this region. Similarly, relationships of ground temperature, water regime, soil conditions and associated vegetation studies are required not only to reclaim disturbed areas but to avoid areas that are potentially problematic. Some programs are being conducted by agencies such as the ALUR Program (Dept. of Soil Science, 1971, 1972) and the Department of the Environment (Crampton, 1972 , 1973).

4. STUDY AREA

4.1 Geographic Location

The strip of land under consideration (Figure 1) is located in the Southwest District of Mackenzie, North West Territories, north of Wrigley, the one settlement in the area. There are scattered seasonal Indian fishing camps along the bigger rivers. Fort Simpson, located at the confluence of the Liard and Mackenzie Rivers, is the major settlement to the south. An all-weather road connects Fort Simpson to the Mackenzie Highway at Enterprise, N.W.T.; as yet, there is no road connecting Wrigley with other settlements along the Mackenzie although one is under construction. During winter, vehicles are able to use the 'winter tractor road' between Fort Simpson and Blackwater Lake. A commercial airline has scheduled flights between Wrigley and Fort Simpson, where charter aircraft are available. The Mackenzie and Liard Rivers provide routes for water transport.

The study area, 3000 sq. km., contained within the coordinates 122°00'-125°00'W, longtitude, 63°24'-63°34'N. latitude, lies in the northern part of the Interior Plains containing the Mackenzie Plain and east of the Mackenzie Mountains. The Interior Plains are flat to gently rolling with elevations of 300 to 750 m. The two major mountain ranges in the area are the Canyon Range of the Mackenzie Moutains (up to 1000m.) and the McConnell Range of the Franklin Mountains (up to 1700m.).

Figure 1. Geographic of study area

4.2 Climate

The study area is located north of the summer limit of permafrost (Brown, 1970). The sub-arctic climate (Brandon, 1965) is typified by a cool, short summer with temperatures above 10^{o}C. and by long, cold winters which have undoubtedly led to considerable ice buildup in some of the different kinds of terrain in the Wrigley area (Table 1).

4.3 Geology

The geology of the area has been studied and documented by Craig (1965), Hume (1954), Stott (1960) and Douglas and Norris (1960). The entire lowland area is covered by a continuous mantle of glacial and postglacial deposits. There are two Cordilleran regions within the study area, the Canyon and McConnell Ranges that are covered for the most part by a shallow veneer of glacial drift deposits. There are extensive areas of organic terrain, especially in the central part of the Wrigley 1:2500,000 NTS map sheet. At the eastern extremity of the study area, there are coarse-textured, glacial outwash deposits and eroded glacial till deposits that produce a pockmarked appearance on the landscape. Lacustrine and alluvial deposits are found near the Mackenzie River and areas of shallow lacustrine deposits over glacial till are found in the Dhadinni 1:250,000 NTS map sheet. Mixtures of colluvium and alluvium are common on the more sloping land near the mountain ranges. Throughout the area, there are outcrops of

Table 1. Selected climatic data of the Wrigley area

	TEMPERATURE (°C)					PRECIPITATION (CM)		
Month	Mean Maximum	Mean Miminum	Maximum	Minimum	No. of days with freezing temperature	Total	No. of days with 0.01 or more	Snowfall
January	-27.0	-34.8	- 9.9	-45.1	31	1.95	10.9	19.5
February	-20.2	-29.8	- 7.4	-43.1	28	1.25	8.6	12.5
March	-11.3	-23.1	3.3	-36.7	31	0.98	7.6	10.0
April	3.2	9.9	13.3	-23.0	27	1.52	6.8	13.5
May		0.6	23.7	7.0	14	2.30	7.0	4.8
June	13.6	7.1	28.7	- 0.3	1	3.60	9.1	0.0
July	20.6	9.6	30.8	1.8	0.3	5.03	10.7	0.0
August	22.5	7.0	28.3	- 1.1	1.6	4.78	9.3	0.0
September	20.2	0.3	20.3	6.0	10	3.32	8.4	3.5
October	11.3	- 5.8	12.6	-18.6	28	2.70	9.2	20.8
November	0.9	-22.2	- 1.8	-35.2	30	2.12	10.7	22.5
December	-21.8	-26.3	-10.8	-42.4	31	2.10	9.3	20.0

flat-lying sedimentary rocks covered by a thin veneer of glacial till. In many instances, these areas are difficult to detect from the air photograph. This surficial geology will be reported in more detail by Dr. N.W. Rutter, G.S.C. and Dr. C.B. Crampton, Department of the Environment.

5. METHODS AND SOURCES OF DATA

The inventory of the area was carried out at a broad reconnaissance or exploratory level. The mapping is presented on three aerial photograph mosaics obtained from the National Air Photo Library, Department of Energy, Mines and Resources. Each of these mosaics is at a scale of one inch to one mile and together they constitute a strip running from 122°00' to 125°00' longtitude.

(Please note: The user is cautioned that each of these mosaics is semicontrolled and as a result, there are several areas where the sequential photography is not pieced together in the proper manner).

Each mosaic has its own legend which is set up to be used consecutively with the text. Each is written so as to allow easy access to the other. The legend has been established employing geologic materials, landform, soils, texture, drainage, associated vegetation and additional noted for each mapping unit. The accompanying text is written in the same format.

Soils were mapped as soil associations (geographically associated soils) within each geologic material. The landforms and geologic material are those in current usage by the Geological Survey of Canada. Soils were classified at the subgroup level (CSSC, 1970) since this level of classification best suits the scale of mapping and of environmental inventory employed. Each

soil association consists of a dominant soil(s) (comprising greater than 40 percent of the mapping unit) and significant soils (comprising 20 to 40 percent of the mapping unit) whenever applicable.

The mapping units are described in section 6 with a brief description of the characteristic soils and vegetation. Common names are used to describe the soils throughout the section, the scientific names are in Appendix 12.2. A more detailed description of the soils and vegetation is presented in Appendix 12.2 and the laboratory results of selected chemical and physical data of the major kinds of soils are presented in Appendix 12.3. The reader is referred to the ALUR Report 71-72 for more complete definitions of the mineral and organic types of soil.

Over fifty sites typical of the areas where ground truthing was carried out were examined in detail for soil and vegetation. At each site all the vegetative layers were examined and, for each stratum, the species compostion was recorded with the dominant species indicated and, a percentage ground cover was estimated for each vegetative layer.

Since the soil and vegetation were sampled simultaneously a each site, it was decided to examine the relationship between vegetation and drainage class, as well as the relationship between

vegetation and soil. In some cases the differences in vegetation between the two groupings is nebulous since some soils fall into one drainage class but where one soil crosses several drainage classes, differences may be significant.

Based at the G.S.C. field camp at Wrigley, the field party comprising, R. Beale, P.A. Dairon, D.S. Lacate, L.M. Lavkulich, T. Lewis and M.E. Walmsley, all from University of British Columbia, operated in two, separate multi-disciplinary groups developing ground truths to substantiate aerial and air photographic reconnaissance.

6. RESULTS

6.1 Appraisal of Soils Vegetation and Landform Relationships, Wrigley and Dahadinni Areas, N.W.T.

In general, the mapped area from west to east begins in the Canyon Range of the Mackenzie Mountains in the Dahadinni area. This mountain range consists mainly of dolomites, limestones and calcareous shale bedrock of marine origin. Toward the east, it grades into an undulating shallow glacial till, over various types of bedrock, and areas containing a mixture of colluvium, alluvium and glacial till. South of the Johnson River there is a slight but quite extensive depression consisting mostly of a thin veneer of lacustrine material over glacial till of the same texture and grading into an undulating till plain. Towards the Mackenzie River, there is an area of lacustrine deposits that grades gently into the alluvial terraces of the Mackenzie River. These same materials are found on the east bank of the river. The alluvial terraces grade eastwards into an extensive lacustrine plain area. The McConnell Range (1,700 m) of the Franklin Mountains is next. South of the mountain pass through which the Ochre River flows, the bedrock is dominantly quartzite, sandstone and shale while north of the Ochre River there are large areas of limestone and dolomite bedrock. East of the mountains, long sloping colluvial-alluvial fans extend into large organic areas dominated by extensive polygonal bogs. These in turn grade into a very large area of drumlinized or

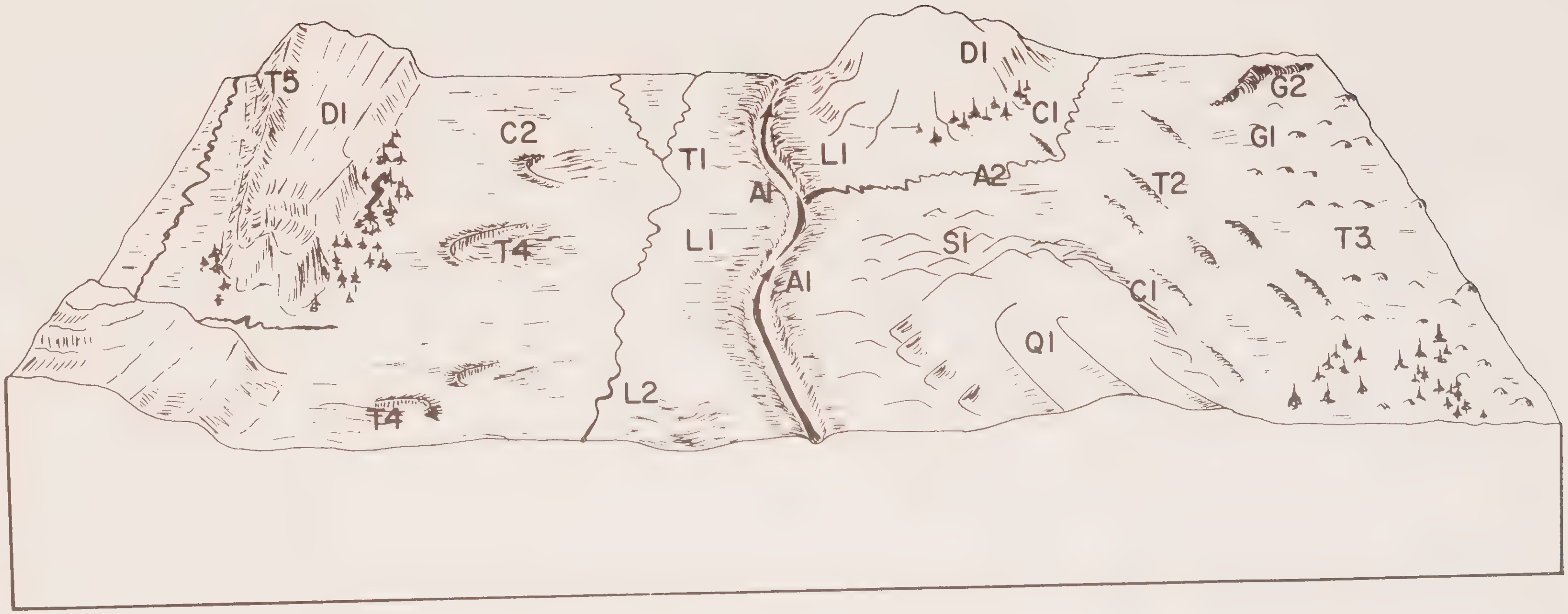

Figure 2. Schematic diagram of study area

(See Table 2 for definition of symbols)

fluted till with large amounts of organic deposits. At the far eastern end of the study area, the landscape is very irregular and is characterized by a pock-marked appearance on topographic maps and air photographs. These deposits are water-dissected, glacial till deposits. North of this is an area of glacial outwash material composed of kames, eskers and esker complexes (Figure 2, Table 2).

Alluvium; alluvial terrace or plain - Al

Adjacent to the Mackenzie River there are relatively extensive terraces of alluvial material (Figure 3). The texture of this material is dominantly silt loam but is quite variable. The dominant soil in this area is a moderately well-drained Degraded Dystric Brunisol on slopes of 5-10%. A typical soil has 5 cm of decomposing organic litter; 5 cm of partially decomposed organic material; 2 cm of a light gray silt loam Ae; 9 cm of a pale yellow, clay Bm; 22 cm of a light yellowish brown loam BC underlain by a light yellowish gray, silt loam Ccaz. The dominant vegetation consists of a mixture of white spruce, birch, rose, labrador tea, bunchberry, cowberry, Comandra, feathermosses and reindeer mosses.

The significant soil of the area is found in imperfectly- to poorly-drained receiving positions on the slope. This soil is a Peaty Rego Humic Gleysol and has 9 cm of moss remains over

Table 2. Relationship between geologic material, landform and soil associations

Geologic Material	Landform	Texture	Symbol	Dominant Soil	Significant Soil
Alluvium	alluvial terrace or plain	variable (dominantly silt loam)	A1	Degraded Dystric Brunisol	Peaty Rego Humic Gleysol
	floodplain	variable (dominantly silt loam)	A2	Cumulic Regosol	
Colluvium	colluvial fan	gravelly loamy sand to gravelly sandy loam	C1	Orthic Gleysol	Peaty Orthic Gleysol
	colluvial plain	gravelly sandy loam to gravelly loam	C2	Alpine Eutric Brunisol	Peaty Orthic Humic Gleysol
Glacial till	till plain	silt loam to clay loam	T1	Degraded Dystric Brunisol	Peaty Rego Humic Gleysol
			T1.1	Peaty Rego Humic Gleysol	Cryic Fibrisol
	drumlinized till plain	gravelly sandy loam to gravelly loam	T2	Degraded Dystric Brunisol	Orthic Humic Gleysol Cryic Fibrisol
			T2.1	Peaty Orthic Humic Gleysol	Cryic Fibrisol Degraded Dystric Brunisol

Table 2. (continued)

Geologic Material	Landform	Texture	Symbol	Dominant Soil	Significant Soil
	eroded till plain	gravelly sandy loam	T3	Degraded Eutric Brunisol	Cryic Fibrisol
	till shallow to bedrock	silt loam to clay loam	T4	Degraded Dystric Brunisol	Peaty Rego Humic Gleysol
	till complex	gravelly loam	T5	Degraded Dystric Brunisol	Peaty Rego Humic Gleysol
Glacial outwash	kames and esker segments	gravelly loam to gravelly sandy loam	G1	Degraded Dystric Brunisol	Degraded Eutric Brunisol Gleyed Degraded Dystric Brunisol
	esker and esker complex	gravelly sandy loam	G2	Orthic Eutric Brunisol	
			G2.1	Gleyed Degraded Dystric Brunisol	Cryic Fibrisol
Lacustrine	lacustrine plain	silty clay	L1	Orthic Gray Luvisol	Orthic Humic Gleysol
					Cryic Fibrisol
	lacustrine shallow over till	clay	L2	Orthic Gray Luvisol	Humic Eluviated Gleysol
					Cryic Fibrisol
Shales	bedrock	gravelly sandy loam	S1	Lithic Alpine Dystric Brunisol	

Table 2. (Continued)

Geologic Material	Landform	Texture	Symbol	Dominant Soil	Significant Soil
Quartzite and	bedrock	gravelly loamy sand	Q1	Lithic Degraded Dystric Brunisol	Alpine Eutric Brunisol
Dolomite, Lime-stone and calcareous shales	bedrock	gravelly loam	D1	Alpine Eutric Brunisol	
Organic	fen	fibric	O1	Fenno Fibrisol	
	peat plateau	fibric	O2	Cryic Fibrisol	Cryic Mesisol
	polygonal bog	fibric	O3	Cryic Fibrisol	

15 cm of partly decomposed organic matter over 10 cm of decomposed organic matter; 7 cm of a very dark grayish-brown, loam-textured Ah horizon underlain by a dark grayish-brown, loam-textured Cgz horizon. Ice was detected at approximately 40 cm. Vegetation consists dominantly of black spruce, labrador tea, moorwart, horsetail, feathermosses and reindeer mosses.

Alluvium; creek floodplain - A2

This unit describes the soils found on floodplains along small creeks and rivers (Figure 4). The dominant soil in this area is a Cumulic Regosol. It is a moderately well- to imperfectly-drained soil of variable texture; dominantly silt loam. A typical soil has 10 cm of decomposing organic material; 8 cm of a very dark brown, silty clay loam Ah; 11 cm of a very dark grayish-brown, loam Cl underlain by a very dark brown, silt loam CII. The vegetation is dominated by a mixture of white spruce, bog birch, labrador tea, cowberry, bunchberry, feather-mosses and reindeer mosses. There are areas within this unit containing larger amounts of organic material over the mineral soil.

Colluvium; colluvial fan - Cl

On the east side of Cap Mountain and on other steep areas, there are soils derived from a mixture of colluvium, alluvium

and glacial till (Figure 5). The material is generally of a gravelly loamy sand to gravelly sandy loam texture and consists mainly of coalescing colluvial and alluvial fans. Where there is some soil development the dominant soil is an Orthic Gleysol. A typical example is imperfectly- to poorly-drained and consists of 6 cm of decomposing organic material; 4 cm of charcoal (from a recent burn); 9 cm of a brown, sandy loam Bg; 12 cm of a reddish brown, loamy sand BC underlain by a dark reddish-gray, loamy sand C horizon. The vegetation consists dominantly of stunted white spruce, bog birch, willow, sedges and reindeer mosses.

Associated with these soils, mainly in depressions in the landscape, are Peaty Orthic Gleysols. Due to the complex nature of the slopes in the area, these soils are found in very close association with the dominant soil. A typical profile consists of 6 cm of undecomposed fibric organic matter; 22 cm of intermediately decomposed organic matter underlain by a loamy sand Bg or Cg horizon similar to that described for the dominant soil, C1.

Colluvium; colluvial plain - C2

This area, mainly on the east side of Cap Mountain, is a moderately steep colluvial plain deeply dissected by water channels (Figure 6). The slopes in this area are simple and

range from 8 to 15 percent. The dominant soil is a well- to moderately well-drained Alpine Eutric Brunisol of gravelly sandy loam to gravelly loam texture occurring on 5 to 10 percent slopes. A typical soil has 6 cm of a dark yellowish brown, gravelly loam textured, turfy Ah horizon; a pale brown, sandy loam Bm underlain by an olive brown, sandy loam C horizon.

Associated with this soil is an imperfectly to poorly drained Peaty Orthic Humic Gleysol. This soil is developed in the alpine meadows that are often found in more level areas on the colluvial slope. These meadows are typically very hummocky due to solifluction and cryoturbation. No doubt they are receiving areas for much of the material moving downslope. A typical profile has 5 cm of organic litter material; 8 cm of decomposing organic material; 11 cm of a very dark brown, turfy, sandy clay loam Ah horizon; 19 cm of a gray brown, clay loam Bg horizon underlain by a grayish brown, sandy loam C horizon. The bedrock is dominantly shaly.

<u>Glacial till; till plain</u>

There are many areas throughout the study strip where this mapping unit occurs. Generally, the topography is quite irregular and undulating. This association is made up of two parts: Tl and Tl.l.

Tl association

The soils of this association are found on long slopes (approximately 10%) and have a Degraded Dystric Brunisol as the dominant soil. Typically, it consists of 8 cm of decomposing organic material; 2 cm of a light gray Ae horizon; 7 cm of a light yellowish-brown, silt loam Bm horizon; 15 cm of a very pale brown, loam BC horizon underlain by a light brownish-gray, loam to silt loam C horizon. The gleyed member of this soil is often found in close association. Characteristic vegetation consists mainly of black spruce, labrador tea, various shrubs, herbs, feathermosses and reindeer mosses.

Associated with this soil in imperfectly to poorly drained depressional areas and in receiving positions on the slope is the significant soil of the association. This soil is a poorly-drained, sandy loam, Peaty Rego Humic Gleysol. A typical profile comprises 15 cm of decomposing organic litter; 15 cm of partially-decomposed organic material; 10 cm of a very dark brown, sandy loam Ah horizon underlain by a brown, sandy loam Cg horizon. The vegetation on these sites is dominated by black spruce, labrador tea, feathermosses and reindeer mosses.

Tl.1 association

The soils of this association are located usually in the poorly-drained, side-hill bog areas and in depressions (Figure 7).

The dominant soil is a Peaty Rego Humic Gleysol identical to the significant soil of the T1 association. A Cryic Fibrisol is the significant soil of the association and occurs in larger depressions where there are extensive areas of accumulated raw sphagnic organic matter. These areas have a dome-like appearance and are frozen at very shallow depths (approximately 32 cm). This type of organic terrain is called a Peat Plateau and has a hummocky surface with thaw pockets where the ice has melted. A typical profile has 5 cm of living mosses over approximately 27 cm of raw, undecomposed sphagnum mosses to frozen ground. Due to the hummocky nature and thaw pockets, the depth to ice is variable. The vegetation is scattered black spruce, labrador tea, bog birch, baked appleberry, crowberry, blueberry, cowberry, Comandra, reindeer mosses and sphagnum mosses.

This association is typical of the central part of the Dahadinni area.

Glacial till; drumlinized till plain

This association is made up of two parts: T2 and T2.1.

T2 association

The T2 association is found on stream-lined, loamy glacial till deposits. The dominant soil is a moderately well-drained Degraded Dystric Brunisol, found on slopes of 5-30%

(Figure 8). These soils have a thick litter layer of decomposing organic material; 2 cm of a pinkish gray Ae horizon; 13 cm of a yellowish red, sandy clay loam Bm horizon; 6 cm of a strong brown, sandy loam BC horizon underlain by a brown, loam C horizon. The vegetation consists of a mixed forests of white spruce, jack pine and aspen with an understory of alder and a ground cover of bunchberry, cowberry, Pyrola and sparse feathermosses.

The significant soil, an Orthic Humic Gleysol, occupies the moderately poorly-drained, 5-8% slopes where they receive groundwater from the surrounding well-drained soils. A typical profile has about 12 cm of decomposing organic material; 8 cm of a dark yellowish brown, sandy loam Bg horizon underlain by a very dark grayish brown Cg horizon.

In extensive areas between the stream-lined forms of glacial till there are organic deposits similar to those described for the Tl.1 association (Figure 9). The soils are poorly-drained Cryic Fibrisols associated with peat plateau areas and with dominant vegetation similar to of the Tl.1 - Cryic Fibrisol.

T2.1 association

The T2.1 association consists of a mixture of moderately poorly-drained Peaty Orthic Humic Gleysols, poorly-drained Cryic Fibrisols and minor inclusions of moderately well-drained Degraded Dystric Brunisols. This situation is termed a slope bog and is

differentiated from a peat plateau area by the higher percentage of stunted black spruce with sphagnum mosses, reindeer mosses and a larger amount of feathermosses. The moderately well-drained soils seem to occur as islands in the matrix of poorly-drained members (Figure 10).

Glacial till; eroded till plain - T3

In the extremely hummocky, pock-marked eastern limit of the study area, the material is glacial till that has been subsequently eroded by water. The topography has the appearance of the classical knob and kettle landforms typical of glacial outwash materials (Figure 11). The dominant soil is a moderately well-drained, gravelly, sandy loam Degraded Eutric Brunisol. A typical profile consists of a thin layer of decomposing organic matter; a thin, light brownish-gray, sandy loam Ae horizon; 12 cm of a strong brown, sandy loam Bm1 horizon; 5 cm of a dark yellowish brown, clay loam Bm2 underlain by a calcareous, brown, sandy loam Cca horizon. The vegetation is dominated by black spruce, lodgepole pine*, birch, various shrubs, herbs, feathermosses and some reindeer mosses.

Within the matrix of hummocky till remnants, there are poorly-drained areas where a Cryic Fibrisol is the dominant soil on shallow slopes of about 5%. It is frozen at approximately 30 cm.

*The identification of this species is subject to confirmation

Glacial till; shallow to bedrock - T4

Throughout much of the Dahadinni area there are places where bedrock is close to the surface (Figure 12). Most of the bedrock in these areas is flat lying and only partially exposed on one side. The dominant soil is developed from silt loam to clay loam textured material. This soil is a moderately well-drained Degraded Dystric Brunisol similar to that described for Tl - Degraded Dystric Brunisol. It appears that the texture may vary due to the different rock types and depth of consolidated material but is dominantly silt loam to clay loam. Vegetation consists mainly of black spruce, lodgepole pine, birch, feather-moss and reindeer mosses.

As with the dominant soil of this association, the significant soil and vegetation are similar to those described in the Tl association.

Glacial till; till complex - T5

In alpine and sub-alpine valleys and on some mountain slopes, there are soils derived from differing proportions of glacial till, colluvium and alluvium (Figure 13). The material is mainly of a gravelly loam texture and the soil is moderately well- to imperfectly-drained. The soil is a Degraded Dystric Brunisol consisting of 9 cm of decomposing organic matter; 3 cm of a light brownish-gray, silty clay loam Ae horizon; 8 cm

of a very pale brown, silt loam Bm horizon; 14 cm of a pale olive, silty clay loam BC horizon underlain by a light brownish gray, loam C horizon. The vegetation consists mainly of black spruce, labrador tea, various herbs, feathermosses and reindeer mosses.

In the poorly drained, receiving positions on the slope a Peaty Rego Humic Gleysol soil is developed. Typically the profile consists of 25 cm of undecomposed, fibric organic matter, 10 cm of intermediately decomposed organic matter; 8 cm of a dark brown, sandy loam Ah horizon underlain by a brown, sandy loam Cgz horizon. There is evidence of much frost churning in these soils with some ice lenses. The dominant vegetation comprises black spruce, bog birch, shrubs, herbs and reindeer mosses.

Glacial Outwash; kames and esker segments - Gl

Toward the north-eastern edge of the study strip there are extensive areas of outwash deposits containing esker segments, pitted outwash and washed glacial till (Figure 14). The pitted outwash deposits have gently sloping kames and steep-sided kettle holes. The soil is a mixture of Degraded Dystric Brunisols, Degraded Eutric Brunisols and Gleyed Degraded Dystric Brunisols. The dominant soil (Degraded Dystric Brunisol) is moderately well-drained, well-sorted sands and gravel on slopes

of 10-20%. A typical soil has a thin layer (4 cm) of decomposing organic material; 8 cm of a light gray, silt loam Ae horizon; 25 cm of a yellowish red, gravelly loamy sand Bm horizon underlain by a calcareous, brown, gravelly coarse sand Cca horizon. The vegetation is mainly white spruce, black spruce, labrador tea, kinnikinnik, rose, bunchberry, reindeer mosses and various other lichens.

One of the significant soils is a Degraded Eutric Brunisol which occurs on slightly stratified kame deposits and is well-drained. The soil is calcareous at 25 cm and the slopes range from 30-40%. A typical profile consists of a thin layer of organic litter material; 5 cm of a light gray, loam Ae horizon; 10 cm of a dark yellowish brown, clay Bm; 8 cm of a brown, clay loam BC underlain by a dark grayish-brown, gravelly loam Cca horizon. The material did not appear to be as well sorted as the previous soil and the finer texture suggests some mixing of outwash and till materials.

The other significant soil of this association occurs in the receiving position at the base of the ridge or hummock. It is an imperfectly- to poorly-drained Gleyed Degraded Dystric Brunisol. This soil appears to consist of more or less sorted sands and gravels with ice at 75 cm. A typical profile comprises a thick (10 cm) layer of decomposing organic material; 3 cm of a pinkish gray, sandy loam, Ae horizon; a brown, loam Bmg horizon

underlain by a dark brown BC horizon and a frozen C horizon. The vegetation is predominantly black spruce, labrador tea, rose, Comandra, feathermosses and reindeer mosses.

Glacial Outwash; esker and esker complex

In the same general geographic location as the G1 association, occur areas of esker and esker segments. This area is made up of two associations; G2 and G2.1.

G2 association

On the elevated areas or tops of the esker ridges the soil is well- to rapidly-drained gravelly sandy loam (Figure 15). The material consists of roughly sorted sands and gravels and the slope varies from 5-30%. The dominant soil is an Orthic Eutric Brunisol consisting of 4 cm of decomposing organic litter; 15 cm of a yellowish brown, sandy loam Bm horizon underlain by a brown gravelly sand CI horizon over a pale brown, gravelly sand CII horizon. The vegetation is dominated by white spruce, birch, jack pine, alder, cowberry, fireweed and Peltigera. The area has been recently burned.

G2.1 association

At the base of the ridge or hummock and in other receiving areas an imperfectly- to poorly-drained Gleyed Degraded

Dystric Brunisol similar to that described for the Gl association has developed. No ice was located in this soil but the vegetation is the same as Gl - Gleyed Degraded Dystric Brunisol.

Within the matrix of outwash material there are poorly-drained areas of open bogs and peat plateaux (Figure 16). These areas usually follow poorly-defined drainageways and are similar to the Cryic Fibrisols previously mentioned. Closely associated with these deposits are Cryic or Terric Mesisols (fen deposits). These are sedge-covered, very wet areas, that have a black, moderately decomposed, organic layer with variable depth to ice.

Lacustrine; lacustrine plain - Ll

On both sides of the Mackenzie River, adjacent to the alluvial deposits are silty clay textured lacustrine deposits (Figure 17). As a rule, the lacustrine deposits occupy positions of lower elevation than the glacial till deposits. The dominant soil is a moderately well- to imperfectly-drained Orthic Gray Luvisol of a silty clay texture. The slopes in this area range from 5-15%. A typical soil has a thin layer of decomposing organic litter; a thin, pinkish gray, Ae horizon; 17 cm of a grayish brown, clay Bt horizon; 20 cm of a light brownish-gray, silty clay BC horizon underlain by a light brownish-gray, clay Cca horizon. The characteristic vegetation consists of balsam poplar, white spruce, alder, rose, twinflower, bunchberry, cowberry,

feathermosses and Peltigera.

The poorly-drained member of this association forms one of the significant soils. This is an Orthic Humic Gleysol, frozen at 38 cm, and located mainly in the receiving areas on the landscape. A typical profile consists of 8 cm of decomposing organic material; 6 cm of a turfy, very dark brown, Ah horizon; 28 cm of a dark reddish brown Bg horizon underlain by a very dark gray, frozen Cz horizon. The strata are subject to much cryoturbation and mixing. Associated vegetation consists of black spruce, alder, labrador tea, baked appleberry, sphagnum and reindeer mosses.

The other significant soils of this association are Cryic Fibrisols with raw, undecomposed sphagnum peat deposits frozen at shallow depths (35 cm). These soils occupy the more depressional or poorly drained positions on the landscape. The dominant vegetation is black spruce, bog birch, sweet gale, roundleaf sundew and sphagnum. These peat plateau and slope bog areas are intermingled throughout the entire lacustrine plain area.

<u>Lacustrine; lacustrine shallow over till - L2</u>

South of the Johnson River, there is an extensive depression in the landscape. There is a shallow capping of clay textured lacustrine material overlying glacial till material of the same

texture (Figure 18). The dominant soil is an imperfectly-drained Orthic Gray Luvisol occurring on the topographic highs of the quite variable and undulating landscape typical of this area. The soil consists of 7 cm of decomposing organic material; 5 cm of a light olive brown, silty clay Ae horizon; 10 cm of a very dark grayish brown, silty clay Bt horizon underlain by a dark olive gray, clay C horizon. The material is frozen at 40 cm.

One of the significant soils of this association is located mainly in the drainageways extending downslope (these drainageways produce a dark stringer appearance on the air photo mosaic due to the abundance of black spruce). It is a poorly-drained Humic Eluviated Gleysol and consists of a thick layer of decomposing organic material (<10 cm); 7 cm of a turfy, dark brown, Ah horizon; 5 cm of a very dark grayish-brown, Ae horizon; 25 cm of a dark reddish brown, clay Btg horizon underlain by a dark olive gray, clay Ccag horizon. The soil is frozen at 45 cm.

In the more depressional and flat areas on the landscape, organic material has accumulated as peat plateau. The soil is a Cryic Fibrisol, similar to that in Ll. It is also frozen at approximately 30 cm and supports similar vegetation.

<u>Shale; shallow to bedrock - Sl</u>

In the mountainous areas and slopes on the east face

of Cap Mountain and in some smaller areas north of the Ochre River there are moderately well-drained soils formed essentially from shale bedrock (Figure 19). The material is a gravelly sandy loam extremely red coloured due to the shale bedrock. The dominant soil is a Lithic Alpine Dystric Brunisol developed on slopes of 5-40%. A typical profile consists of 5 cm of decomposing organic material; 7 cm of dark reddish gray, medium sand textured Ah horizon; 15 cm of a brown, loamy sand Bm horizon underlain by a weak red, sandy loam textured C horizon. The dominant vegetation consists of white spruce (krummholz) bog birch, rose, shrubby cinquefoil, Arnica, gray goldenrod and reindeer mosses (Figure 20). This soil moves freely downslope under the influence of gravity on the flat-sided fragments of bedrock.

Quartzite and Sandstone; shallow to bedrock - Ql

On the top and south face of Cap Mountain there are areas of classic felsenmeer landscape (Figure 21) with many large shattered blocks of rock disintegrating into smaller blocks. Some of the crevasses in the rock extend down for several metres or more. Where there is soil material, the dominant soil is a Lithic Degraded Dystric Brunisol, a gravelly loamy sand, moderately well-drained and occurring on 8-20% slopes. The soil consists of 5 cm of decomposing organic material; 3 cm of a light

brownish-gray, loamy sand Ae horizon; 8 cm of a dark reddish-brown, loam Bm horizon; 10 cm of a reddish-brown, sandy loam BC horizon, underlain by a dark grayish-brown, gravelly loamy sand C horizon, over quartzite or sandstone bedrock. The characteristic vegetation is bog birch, labrador tea, crowberry, cowberry and reindeer mosses.

The significant soil of this association, an Alpine Eutric Brunisol, occurs where there is deeper soil accumulation (Figure 22). It is moderately well-drained and the depth to bedrock is 60 to 100 cm. Typically, it comprises a thin layer of decomposing organic material; 4 cm of a turfy, dark reddish-brown, sandy clay textured Ah horizon; 16 cm of a brown, loam Bm horizon; 14 cm of a grayish brown, clay loam BC1 horizon; 15 cm of grayish-brown, clay loam BC2 horizon underlain by a dark brown, clay loam textured C horizon. The vegetation is dominantly bog birch, roundleaf sundew, crowberry, cowberry and lichens.

There are many areas of stone stripes and stone rings in this area (Figure 23) as well as some areas of alpine meadows (Figure 24) where there is some accumulation of organic material.

<u>Dolomites, Limestone and Calcareous Shales - shallow to bedrock - D1</u>

This association occurs mainly in the Canyon Range of the Mackenzie Mountains in the Dahadinni area (Figure 25). For the most part, these are relatively deep soils, the dominant member

being an Alpine Eutric Brunisol. This is a moderately well-drained gravelly loam with much exposed bedrock. A typical profile consists of a thin layer of decomposing organic material; 10 cm of a dark brown, turfy, loam Ah horizon; 5 cm of a brown, silt loam to clay loam Bm; 10 cm of a yellowish-brown, gravelly loam BC horizon underlain by a light brownish-gray, calcareous, gravelly loam Cca horizon. The dominant vegetation consists of "krummholz" white spruce and larch, bog birch, willow, kinnikinnik, feathermosses and reindeer mosses.

Organic; fen - O1

In small areas throughout the entire study strip there are soils derived from moderately-decomposed sedge deposits. These areas generally have a high water table with nutrient-rich waters draining from surrounding mineral soils (Figure 26). The dominant soil in such areas is a Fenno Fibrisol composed of moderately- to well-decomposed sedge peat. The vegetation consists mainly of stunted black spruce, bog birch, willow, labrador tea, cowberry, Pyrola, baked appleberry, sphagnum and feathermosses.

Organic; peat plateau - O2

These are quite extensive organic deposits derived mainly from sphagnum (Figure 27). The surface is quite irregular and hummocky, usually raised 1 to 2 metres above the surrounding

minerotrophic fen deposits (Figure 28). The dominant soil is a Cryic Fibrisol derived from raw, undecomposed sphagnum peat, frozen at 30 cm. The associated vegetation consists of scattered black spruce, labrador tea, Andromeda, cowberry, baked appleberry, sphagnum and reindeer mosses.

The significant soil of this association is a very poorly drained Cryic Mesisol usually found at the base of the peat plateaux, along the edges, connecting them together. It is usually frozen at 45 cm or deeper. Dominant vegetation consists of bog birch, willow, scattered tamarack, black spruce, sedges and sphagnum mosses.

Organic; polygonal bog - 03

East of Cap Mountain, there are extensive areas of organic terrain made up of large lichen-covered bogs (Figure 29). These bogs have cracks forming polygons of 15 to 20 metres in diameter outlined by fissures of variable width sunk about one-half metre below the surrounding terrain. The soils are poorly drained Cryic Fibrisols and consist of 30 cm of black, moderately decomposed organic materials over raw, undecomposed sphagnum peat with ice at 10 to 15 cm. The associated vegetation is bog birch, arctic labrador tea, baked appleberry, sphagnum and reindeer mosses.

6.2 Vegetation and Landscape - Wrigley, N.W.T.

Vegetation of Soils Grouped According to Drainage Class

Well-Drained Soils

Well-drained sites such as eskers and kame terraces which are composed of coarse material, i.e., glacial outwash, are typically forested with pure or mixed stands of white spruce and jack pine with white birch, trembling aspen and occasionally black spruce appearing in the understory. Few tall shrubs are present whereas the medium shrub layer, consisting primarily of rose, buffalo berry and juniper, comprises about 20% of the ground cover. Surface cover, consisting predominantly of evergreen shrubs and herbs (cowberry, bearberry, Pyrola and bunchberry) is moderate or about 25-50%. Labrador tea is present on the driest sites. Feathermosses are common and with the lichen *Cladina arbuscula* becoming dominant on drier sites. Soils in the well drained areas include Degraded Dystric Brunisols, Degraded Eutric Brunisols and Orthic Eutric Brunisols. Two examples of stands with the major species in each stratum are listed below:

Site 17-1, esker (material : glacial outwash)

Jack pine	Alder	Bunchberry
White spruce	Buffalo berry	Northern bedstraw
Black spruce	Rose	

Site 17-3, kame (material : glacial outwash)

White spruce	Squashberry	Cowberry
White birch	Juniper	Northern bedstraw
		Pyrola

Moderately Well-Drained Soils

Moderately well-drained sites in the study area, e.g., alluvial ridges, alluvial slopes and the water-shedding slopes of rolling till plains, consist of a variety of materials such as outwash, till, eroded till, alluvium and lacustrine capping over till. These sites are forested with pure stands of white birch, white spruce or black spruce or more commonly with mixed stands of the same with a component of trembling aspen and on the drier sites, some jack pine. These sites have a sparse undergrowth of alder and willows. Typical of moderately well-drained sites is a fairly well-developed, medium shrub layer (ground cover 25-50%) composed of buffalo berry and on the drier sites, labrador tea. Dwarf ericaceous shrubs and feathermoss are abundant under evergreen trees. Typical moderately well-drained soils are Degraded Dystric Brunisols, Degraded Eutric Brunisols and Orthic Gray Luvisols. Three examples follow.

Site 12-1, rolling till plain (material : till)

Black spruce	Labrador tea Blueberry Rose	Cowberry Bunchberry	Feathermoss Cladina arbuscula

Site 9-3, alluvial ridge (material : alluvium)

Black spruce White spruce	Alder Labrador tea	Cowberry	Feathermoss

Site 18-2A, rolling till plain (material : lacustrine veneer over till)

White birch	Labrador tea Rose	Bunchberry Coltsfoot

Imperfectly-Drained Soils

Imperfectly-drained soils, found in the receiving areas of rolling till plains, drumlinized till plains, alluvial floodplains and lacustrine plains, are composed of varying combinations of till, alluvium and lacustrine material. Forests on these sites consist of pure stands of black spruce or of aspen or, more often, mixed forests of white spruce, black spruce and aspen occasionally with larch or balsam poplar. There are few tall shrubs but a moderate cover of labrador tea, rose, blueberry and occasionally bog birch. Shrubby cinqueful appears sporadically in these sites. Coltsfoot, horsetail, Pyrola and cowberry dominate a moderate surface cover. Under evergreen trees, the well-developed moss layer is characterized by feathermoss, _Tomenthypnum nitens_ and _Ptilium crista-castrensis_. The imperfectly-drained class includes a large variety of soils such as Orthic Dystric Brunisols, Degraded Dystric Brunisols, Cumulic Regosols, Orthic Gray Luvisols, Orthic Humic Gleysols and Peaty Rego Humic Gleysols. For examples:-

Site 9-1, lacustrine ridge (material : lacustrine)

Aspen	Alder Rose	Twinflower Pyrola

Site 12-3, till plain (material : till plus alluvium mixture)

Black spruce	Labrador tea Blueberry	Cowberry Horsetail	Ptilium crista-castrensis Reindeer Mosses

Site 25-2, alluvial floodplain (material : alluvium)

White spruce	Rose	Cowberry	Feathermoss
Aspen	Alder	Pyrola	

Poorly-Drained Mineral Soils

Poorly-drained areas such as the receiving portions of rolling till plains, undulating lacustrine plains and alluvial floodplains are characterized by pure stands of black spruce and mixed stands of black spruce and larch with occasional white birch. There are no tall shrubs present whereas the medium and dwarf shrub strata are well developed. Bog birch, labrador tea, cowberry, blueberry and shrubby cinquefoil are typical. The species-poor herb layer is characterized by horsetails and bearberry. The forest floor is hummocky in appearance with occasional hillocks of *Sphagnum* present. Typically the ground is carpeted with varying mixtures of feathermosses, *Aulacomnium palustre*, *Tomenthypnum nitens*, and reindeer mosses. In the poorly drained class are Orthic Humic Gleysols, Humic Eluviated Gleysols, Peaty Orthic Humic Gleysols and Peaty Rego Humic Gleysols. Three examples are given.

Site 10-3, lacustrine plain (material : lacustrine)

Black spruce	Willows	Cowberry	Feathermoss
White birch	Labrador tea	Bearberry	Cladina arbuscula

Site 16-3, till plain (material : till)

Black spruce	Bog Birch	Bearberry	Aulacomnium palustre
	Labrador tea	Cowberry	Cladina arbuscula

Site 18-3, till plain (material : lacustrine capping over till)

Black spruce	Bog birch	Bearberry	Cladina arbuscula
Tamarack	Labrador tea	Horsetail	Cetraria cuculata

Poorly-Drained Organic Soils

(a) Peat Plateaux

Peat plateaux are characterized by an open black spruce forest in which the spruce averages less than 10 m tall. There may be a sparse medium shrub layer of bog birch and sweet gale but there is always a dense understory of labrador tea, moorwart, cowberry, crowberry and small bog cranberry. The species-poor herb layer consists primarily of baked appleberry, bearberry, threeleaf smilax and roundleaf sundew. The surface of the peat plateau is typically composed of Sphagnum mounds which may or may not be lichen-covered. Hair-cap moss and wavy dicranum may be found scattered amongst the hummocks. The associated soil of the peat plateau is the Cryic Fibrisol. An example of the vegetation of the peat plateau follows.

Site 10-2, peat plateau

Black spruce	Labrador tea	Cowberry	Sphagnum fuscum
Tamarack	Blueberry	Bearberry	Reindeer mosses
	Moorwart	Baked Appleberry	

(b) Fen

Fens comprise a very small portion of the study area and therefore only a few were examined. Those studied have a scattered medium shrub layer composed of bog birch and sweet gale

with some labrador tea, leatherleaf, bog laurel, and moorwart. The few herbs present are roundleaf sundew and Tofieldia. Sedges and cotton grass are dominant amongst a few scattered Sphagnum hillocks.

Soils and Vegetation

From a cursory examination of Table 4 one can see that, where a soil falls into one or two drainage categories, the vegetation can be characterized but where a soil crosses many drainage classes as in the case of the Degraded Dystric Brunisol characterization is difficult.

The Degraded Eutric Brunisol is found only in the well- or moderately well-drained areas. It is typically forested with evergreen trees (white spruce or jack pine) occasionally with black spruce, white birch or trembling aspen in the understory. Alder, buffalo berry, squashberry and juniper are sparse (5-25% cover) while the dwarf evergreen shrubs and herbs (cowberry, bunchberry, bearberry) are far more abundant. Feathermosses and lichens are sparse.

Orthic Humic Gleysols and Peaty Rego Humic Gleysols are characterized by black spruce forests which are typical of imperfectly or poorly drained sites.

Orthic Gray Luvisols which fall into the moderate or imperfect drainage classes are generally characterized by pure

stands of white birch, trembling aspen or black spruce with an occasional larch present. A medium and dwarf shrub understory is moderately well developed with squashberry, labrador tea, and rose present. Horsetails are typical of the herb layer. A ground cover of feathermoss develops under deciduous trees.

Alpine Vegetation

Since mountains are a dominant physiographic feature of the landscape, a transect was completed down the side of Cap Mountain to show the variation in vegetation. From the 1170 m level to the coalescing fans at the base of the mountain, three separate units were demarcated (Figure 30). The first unit consists of semi-flat areas or meadows which, at their downslope edge, merge into the sloped second unit called stone stripes (Figure 31). The third unit or rocky area ends in another meadow area and the units are repeated as shown in Figure 32.

The meadow unit (Figure 33), typically, had a well-developed shrub layer consisting of bog birch, willows and shrubby cinquefoil. Predominant in the species rich-herb layer are Dryas, lupine, Anemone, lousewart, spotted saxifrage, monkshood and Arnica. Feathermosses and lichens are abundant.

Vacciniums are dominant on the stone stripes (Figure 34), which run parallel to the slope, rather than bog birch as

in the meadow unit. Dryas and the same herbs as in the meadow are common.

The dry rocky units are being invaded by Dryas, lupine, locoweed, spotted saxifrage, haircap moss, Cetraria cuculata and Cetraria tilesi.

The coalescing fans (Figure 35) at the base of Cap Mountain are vegetated (Figure 36) by scattered krummholz white spruce with a moderate shrub layer including bog birch, vacciniums, willows, rhododendron. Typical herbs are lupine, bearberry and lousewort. The feathermosses are abundant with Cladina arbuscula and Cetraria cuculata present.

Plant Species, Soil Drainage and Soil

The foregoing descriptions of vegetation as related to soil drainage class and soils can be generalized to show the dominant species in each vegetative layer. Table 3 summarizes the relationships between vegetation and drainage class whereas Table 4 shows the relationship between vegetation and soil. As in the Fort Simpson area, mixed tree stands are commonly found in areas that are moderately well- to imperfectly-drained whereas pure stands are more typical of the well- or poorly-drained sites. Unlike Fort Simpson, however, single-species stands were found with regularity in imperfectly-drained areas. With respect to soil, Orthic Gray Luvisols, Orthic Humic Gleysols, Peaty Rego Humic Gleysols often support pure stands whereas Cumulic Regosols, Degraded Dystric Brunisols and Degraded Eutric Brunisols support mixed stands. Tall shrubs are typical of well- and moderately well-drained areas but alder was consistently present in most mineral soil sites. Medium shrubs are present in all areas but most common in the poorly-drained mineral soil sites. Dwarf shrubs are dominant in organic terrain but present in all sites. Horsetail are much more common in the Wrigley study area than in the Fort Simpson area but, as with Fort Simpson, the tall grasses are conspicuously absent.

TABLE 3 VEGETATION - DRAINAGE RELATIONSHIPS

STRATA / DRAINAGE	WELL	MODERATELY - WELL	IMPERFECT	POOR - MINERAL	POOR - ORGANIC (BOG)
TREES	Pinus banksiana Picea glauca Picea mariana	Betula papyrifera Picea glauca Dicea glauca Populus tremuloides Pinus banksiana	Picea mariana Populus tremuloides Picea glauca Betula papyrifera Populus balsamifera	Picea mariana Larix laricina Betula papyrifera	Picea mariana Larix laricina
SHRUBS					
1. Tall, large leaved (leaves exceed 2 x 4 cm)	Alnus crispa Viburnum edule	Alnus crispa Salix spp.	Alnus crispa Salix spp.	Alnus crispa	
2. Medium, small leaved (2 x 4 cm)	Rosa acicularis Juniperus comminus Shepherdia canadensis	Shepherdia canadensis Betula glandulosa Rosa acicularis	Rosa acicularis Betula glandulosa	Betula glandulosa Salix spp. Potentilla fruticosa	Betula glandulosa Myrica gale Salix spp.
3. Dwarf evergreen, ericoids	Vaccinium vitis-idaea Ledum groenlandicum Arctostaphylos uva-ursi	Ledum groenlandicum Vaccinium vitis-idaea Arctostaphylos uva-ursi	Ledum groenlandicum Vaccinium vitis-idaea Vaccinium uliginosum	Ledum groenlandicum Vaccinium vitis-idaea Andromeda polifolia Vaccinium uliginosum	Ledum decumbens Andromeda polifolia Vaccinium vitis-idaea Ledum groenlandicum Empetrum nigrum Vaccinium microcarpon
HERBS					
1. Low, evergreen	Cornus canadensis Pyrola asarifolia Pyrola secunda	Cornus canadensis Linnaea borealis	Cornus canadensis Pyrola secunda Pyrola asarifolia Equisetum scirpoides Lycopodium annotinum	Equisetum scirpoides	
2. Low, deciduous	Galium boreale Commandra livida	Equisetum sylvaticum Arctostaphylos rubra Commandra livida	Arctostophylos rubra Petasites palmatus	Arctostaphylos rubra Equisetum arvense Rubus chamaemorus	Rubus chamaemorous Arctostaphylos rubra Smilacina trifoliata
GRAMINOIDS	Agrostis alba Calamagrostis canadensis	Agrostis alba	Agrostis alba Carex sp. Calamagrostis canadensis	Carex spp.	Carex spp. Eriophorum spp.
FEATHERMOSSES	Hylocomium splendens Pleurozium schreberi	Hylocomium splendens Tomenthypnum nitens Polytrichum juniperinum	Hylocomium splendens Tomenthypnum nitens Ptilium crista-castrensis Polytrichum juniperinum	Hylocomium splendens Aulacomium palustre Tomenthypnum nitens	Polytrichum juniperinum Dicranum undulatum
[illegible]					Sphagnum fuscum

TA DRAINAGE	WELL	MODERATELY - WELL	[illegible]	POOR - MINERAL	POOR - ORGANIC (BOG)
LICHENS	Cladina arbuscula	Cladina alpestris Cladina arbuscula Peltigera aphthosa	[illegible] [illegible] Cladina alpestris	Cladina arbuscula Cladina alpestris Cladina [illegible]	Cladina alpestris Cladina arbuscula Cetraria cuculata

TABLE 4 VEGETATION - SOIL RELATIONSHIPS

STRATA SOIL TYPE	CUMULIC REGOSOL	DEGRADED DYSTRIC BRUNISOL	DEGRADED EUTRIC BRUNISOL	ORTHIC GRAY LUVISOL	ORTHIC HUMIC GLEYSOL	PEATY REGO HUMIC GLEYSOL
DRAINAGE CLASS	IMPERFECT	WELL TO IMPERFECT	WELL TO MODERATELY-WELL	MODERATE (-WELL TO IMPERFECT	IMPERFECT TO POOR	IMPERFECT TO POOR
TREES	Picea glauca Picea mariana Larix laricina Populus tremuloides	Pinus banksiana Populus tremuloides Picea mariana Picea glauca Larix laricina Populus balsamifera Betula papyrifera	Pinus banksiana Picea glauca Betula papyrifera Picea mariana Populus tremuloides	Betula papyrifera Populus tremuloides Picea mariana Larix laricina	Picea mariana	Picea mariana Betula papyrifera Larix laricina
SHRUBS						
1. Tall, large leaved (leaves exceed 2 x 4 cm)	Alnus crispa Salix spp.	Alnus crispa Salix spp.	Alnus crispa Salix spp.	Alnus crispa Salix spp.	Alnus crispa	Alnus crispa
2. Medium, small leaved (2 x 4 cm)	Betula glandulosa Rosa acicularis Shepherdia canadensis	Rosa acicularis Betula glandulosa Juniperus comminus Juniperus horizontalis Shepherdia canandensis	Shepherdia canadensis Viburnum edule Juniperus comminus Rosa acicularis	Rosa acicularis Viburnum edule	Betula glandulosa Potentilla fruticosa Vaccinium uliginosum	Betula glandulosa Vaccinium uliginosum Rosa acicularis
3. Dwarf, evergreen, ericoids	Vaccinium uliginosum Vaccinium vitis-idaea Ledum groenlandicum	Ledum groenlandicum Vaccinium vitis-idaea Vaccinium uliginosum	Vaccinium vitis-idaea Arctostaphylos uva-ursi	Ledum groenlandicum Vaccinium vitis-idaea	Ledum groenlandicum Vaccinium vitis-idaea	Ledum groenlandicum Vaccinium vitis-idaea Ledum decumbens
HERBS						
1. Low, evergreen	Pyrola asarifolia Linnaea borealis	Cornus canadensis Pyrola secunda Pyrola asarifolia	Linnaea borealis Cornus canadensis	Cornus canadensis Linnaea borealis Equisetum scirpoides Pyrola secunda Pyrola asarifolia	Equisetum scirpoides	Equistum scirpoides
2. Low, deciduous	Arctostaphylos rubra	Equisetum sylvaticum Arctostaphylos rubra Comandra livida	Galium boreale Comandra livida	Comandra livida	Arctostaphylos rubra Comandra livida	Arctostaphylos rubra
GRAMINOIDS	Carex sp. Eriophorum sp. Cornus canandensis	Agrostis alba	Cornus canadensis			Agrostis alba

STRATA / SOIL TYPE	CUMULIC REGOSOL	DEGRADED DYSTRIC BRUNISOL	DEGRADED EUTRIC BRUNISOL	ORTHIC GRAY LUVISOL	ORTHIC HUMIC GLEYSOL	PEATY REGO HUMIC GLEYSOL
DRAINAGE CLASS	IMPERFECT	WELL TO IMPERFECT	WELL TO MODERATELY-WELL	MODERATELY-WELL TO IMPERFECT	IMPERFECT TO POOR	IMPERFECT TO POOR
FEATHERMOSSES	Hylocomium splendens Tomenthypnum nitens	Hylocomium splendens Polytrichum juniperinum Tomenthypnum nitens Ptilium crista-castrensis	Hylocomium splendens Dicranum undulatum	Hylocomium splendens Dicranum undulatum Tomenthypnum nitens	Aulacomnium palustre Hylocomium splendens	Aulacomium palustre Hylocomium splendens Tomenthypnum nitens Dicranum undulatum
SPHAGNA						
LICHENS	Cladina arbuscula	Cladina arbuscula Cladina rangiferina Cladina alpestris Peltigera aphthosa	Cladina arbuscula	Peltigera aphthosa Cladina arbuscula Cladina rangiferina	Cladina arbuscula	Cladina arbuscula Cladina rangiferina Cladina alpestris

6.3 Some Relationships Between Soils, Vegetation, And Ground Frost

The distribution of patterns of vegetation communities and ground frost in the Mackenzie lowlands are intimately related to the water and temperature regimes of the soil. The flora, relatively simple and typically Boreal, reflects the harsh regional macro-climate.

The conduction and capacity properties of the soil system, including organic layers, determine the water and temperature regime. They are functions of (1) the composition and arrangement of the solid soil particles and (2) the soil water content throughout the year. The soil fabric, the first of these determinants, is the texture of the geologic material modified to varying degrees by pedogenic processes. Soil water regime, the second determinant is described by soil drainage classes.

Pertinent data collected for this study included July soil temperatures at 20 and 50 cm, field assessment of soil drainage classes, field and laboratory determinations of texture, structure and the 1/10 and 15 bar water retention values and field assessment of vegetative cover.

One tenth and 15 bar soil water contents are used to estimate pore size distribution (Table 5). Coarse-textured soils (loamy sands, loams) tend to have relatively lower 1/10 and 15 bar values than finer-textured soils. Medium-textured soils (silt loams, silts) have high 1/10 bar and moderate 15 bar readings.

Table 5: One-tenth and 15 bar water contents (% by weight) for textures observed

TEXTURE	1/10 BAR		15 BAR		
	MEAN	RANGE	MEAN	RANGE	N
loamy sand & loamy sand to sandy loam	23.94	17.69-34.47	8.79	7.78- 9.97	3
sandy loam	24.66	1.49-63.34	8.35	0.73-23.51	23
loam	22.03	7.85-46.26	7.23	1.09-11.64	15
loam to clay loam & clay loam to loam	23.80	21.19-25.92	8.62	7.26-11.00	4
silt loam	26.12	6.84-37.25	9.64	1.88-14.57	9
clay loam	41.46	17.46-116.27	12.68	3.94-15.89	23
sandy clay loam	24.86	20.00-32.10	6.55	5.19- 7.38	3
sandy clay	28.69	25.47-32.51	5.92	3.75- 8.51	3
silty clay	35.48	30.38-38.61	16.47	10.10-21.74	8
clay	27.20	21.57-40.18	12.66	7.50-20.50	8

Fine textured soils have high 1/10 and 15 bar values. However, water conductivity in fine textured soils is lower than that of medium-textured soils except at low water contents. In the study area, the soils are found on a range of geologic materials and drainage conditions (Table 6). All data relate to July sampling and thus must be interpreted with caution for other times of the year.

Vegetation and ground frost distribution will be discussed under eight headings. The relationship between geologic material and texture, drainage, and soil temperature are indicated (Table 7).

Table 6. The occurrence of soils as a result of the materials-drainage interaction

Material	Drainage: Rapid	Well	Moderately Well	Moderately Poor	Poor	Very Poor
Glaciofluvial	Major	Major	Minor	Minor		
Medium textured till	Minor	Major	Major	Major	Minor	Minor
Fine textured till	Minor	Major	Major	Major	Minor	
Glaciolacustrine		Minor	Major	Major	Minor	
Mesic and humic					Minor	Major
Fibric organic				Major	Minor	

Table 7. July soil temperatures at 20 and 50 cm depth

Geologic material and texture	Drainage	Soil temperature (°C) 20 cm Mean	Range	n	50 cm Mean	Range	n
Fine textured till (silty clay, clay, sandy clay) and silty glacio-lacustrine	Moderately well	7.0	-	1	5.0	-	1
	Imperfectly	6.0	1-9	3	4.0	-	1
	Poorly	2.6	2-3	3	2.0	0-5	3
Glaciofluvial sandy and gravelly	Well	8.6	2-15	6	6.8	0-12	6
Medium textured till (sandy loam to silty clay loam)	Moderately well	6.1	1-12	8	4.4	0.5-10	8
	Poorly	2.3	1-4	4	0.6	-0.5-2	4
Mesic and humic	Very poorly				0.0	-	1
Fibric organic	Imperfect to poor	3.0	1-5	2	0.0	0-0	3

Soils of well-drained sandy and gravelly glaciofluvial materials

These coarse-textured materials are primarily of glaciofluvial origin and landforms include ice-contact kames, pitted and reworked outwash, eskers, crevasse fillings and beach ridges. Degraded Dystric and Eutric Brunisols predominate. The Degraded Dystric Brunisols are characterized by low pH (4.5 to 5.5 in the A and B horizons), low cation exchange capacity and low exchangeable bases. The Degraded Eutric Brunisols are characterized by slightly higher pH values (5.5. in the B horizon) and slightly higher cation exchange capacity and exchangeable cations. The ground temperatures at 20 cm range from 2 to 15^{o}C with a mean of 8.6^{o}C and at 50 cm range from 0 to 12^{o}C with a mean of 6.8^{o}C. Ground frost was not generally encountered in July. Since heat conductivity values are low at low water contents, ambient air temperatures are quickly reflected in the soil system and so these soils freeze quickly in winter and thaw equally quickly in spring.

The vegetation of these materials is very characteristic. Forest cover on these sites is predominantly black spruce, white spruce or jack pine depending on the fire history of the sites. Jack pine is the primary successional vegetation followed by black and/or white spruce. Understory trees include white birch and alder. Shrubs in the understory generally include squash-berry, juniper, rose, labrador tea, and cowberry. Herb species

include northern bedstraw , bunchberry and fireweed, with sparse bluejoint and redtop. Mosses are relatively infrequent. Lichen species cover up to 25 percent of the forest floor depending on the forest tree cover and species include *Cladina* (*Cladonia*) sp. and *Peltigera aphthosa*. The density of the forest understory vegetation, especially shrubs, is greatest on recently burned areas.

Soils of moderately well-drained fine-textured (clay, silty clay) glacial tills and silty glaciolacustrine materials

These fine-textured soils are generally found on glacial till plain and lacustrine plain materials. The till plains are generally fluted while the lacustrine plains are gently rolling. The occurrence of moderately well-drained areas of fine-textured tills and glaciolacustrine materials is relatively minor.

Orthic Gray Luvisol soils predominate, characterized by low pH (3.5 to 5.0) in A and B horizons relatively high cation exchange capacity and moderate exchangeable bases. The pH tends to be higher at greater depths.

Ground frost was not encountered in July. Ground temperatures recorded were $7^{o}C$ and $5^{o}C$ at 20 cm and 50 cm depths, respectively.

The vegetation of these moderately well-drained, fine-textured glacial tills and silty glaciolacustrine materials is

generally characterized by white birch stands with black spruce and alder in the understory. Shrub species are generally limited to cowberry and labrador tea. Bunchberry dominates the herb layer. Feathermosses and lichens are infrequent.

Soils of imperfectly-drained fine-textured glacial tills and glaciolacustrine materials

These materials are generally found in receiving positions on rolling lacustrine plains and fluted or drumlinized till slopes.

Since silty materials have a slightly higher unsaturated hydraulic conductivity than clayey materials the migration of water to zones of freezing and segregated ice formation is more likely in silty soils. The observation of ice in July and the platy structure it generates in silty materials supports this hypothesis. This accumulation of segregated ice lenses in silty material may lead to increased water content and subsequently, to slower heating and thawing the following spring and summer.

The ground temperatures measured for these materials ranged from 1 to 9°C at 20 cm depth with a mean of 5°C. The ground temperature at 50 cm ranged from 0 to 4°C with a mean of 2°C, the silty lacustrine materials being frozen at 40 cm and the clay materials showing no sign of ice at 50 cm.

The imperfectly-drained soils on these fine-textured materials have vegetation differing slightly from the moderately well-drained sectors. The forest cover is primarily mixed white birch and black spruce with understory alder. Labrador tea and rose are conspicuous in the shrub layer. The herb layer is dominated by fireweed with some bluejoint and horsetail. Feathermosses and lichens are common. On recently burned sites, white birch is the commonest species.

Soils of poorly-drained fine-textured glacial tills and glaciolacustrine materials

These fine-textured materials are generally found on undulating to gently or moderately rolling slopes of glacial till slopes, till plains covered with a veneer of lacustrine material of glaciolacustrine plains. The drainage position is primarily receiving or slightly shedding.

Peaty Rego Humic Gleysol soils predominate with Brunisolic Gray Luvisols and Eluviated Gleysols also present. These soils are generally characterized by pH values greater than 5.5 in the A and B horizons, high cation exchange capacity and moderately high exchangeable bases.

The ground temperature fluctuates slowly and over a narrow range due to the poor internal drainage and the thick, protective, insulating organic layer. At 20 cm depth the

temperature in July ranged from2 to 3°C with a mean of 2.6°C, and at 50 cm depth the range was from 0 to 5°C with a mean of 2°C.

Due to drainage and ground temperature differences, there are certain subtle but distinctive differences in characteristic vegetation. The forest cover is primarily scattered black spruce with some aspen and white spruce. Large shrubs are primarily alder, willow and bog birch. Medium and small shrubs include labrador tea, rose, cowberry, and baked appleberry. Herbs are generally found in moderate abundance represented by fireweed, horsetails, and twinflower. Feathermosses are abundant on some sites and lichens too are present although relatively minor.

Soils of moderately well-drained medium textured (sandy loam to silty clay loam) glacial tills

These medium textured moderately well-drained soils are formed primarily on glacial till, eroded glacial till, glacial till plus colluvium, and/or glacial till plus colluvium plus alluvium materials. The landforms diagnostic of these materials are drumlins, rolling till plains, bedrock ridges, and bedrock-controlled till plains. The soils, which are moderately well-drained, are generally found in receiving positions on till slopes.

Brunisols predominate; Degraded Eutric Brunisols or

Degraded Dystric Brunisols or Alpine Dystric Brunisols are the major soils found and their formation depends on the parent material and local climate. The Degraded Dystric Brunisols are characterized by low pH (4.5 to 5.5 in A and B horizons), low cation exchange capacity and relatively low exchangeable bases. The Degraded Eutric Brunisols are characterized by slightly higher pH (5.5 in the B horizon), slightly high cation exchange capacity and higher exchangeable bases. The Alpine Eutric Brunisols are formed in the alpine environments with characteristics similar to Degraded Eutric Brunisols but with less soil development.

Due to improved internal drainage and thermal flow properties in slightly coarser material, ground ice was not encountered at 50 cm depth in July. At 20 cm depths the ground temperatures ranged from 1 to 12°C with a mean of 6.1°C and at 50 cm depths the range was from 0.5 to 10°C with a mean of 4.4°C.

The vegetation found on these moderately well-drained medium textured materials is characteristic. The forest cover is generally sparse, stunted black spruce with lodgepole pine and white spruce on some sites.

Bog birch, labrador tea and rose are moderately abundant. Small shrubs, herbs, graminoids, mosses and lichens are present but in relatively small amounts especially under lodgepole pine regeneration.

Soils of poorly-drained medium-textured glacial tills

These soils are found generally on glacial till, glacial till plus colluvium, eroded glacial till, and/or glacial till plus colluvium plus alluvium in depressional or receiving locations with gleysols primarily being formed. They are generally in the receiving position of rolling till plains, till over bedrock, drumlins or coalescing colluvial fans. The predominant soil types found on these materials with poor drainage are Peaty Gleysols, Rego Humic Gleysols and Peaty Rego Humic Gleysols. They are distinquished by moderate pH (5.5 in the A and B horizons), moderately high cation exchange capacity and exchangeable bases.

These soils are generally not frozen at 50 cm depths in July. This is possibly due to greater thermal conductivity of medium-textured soils compared to fine-textured soils which allows these soils to warm up more quickly and to greater depths in spring and summer. The ground temperature at 20 cm depths had a mean of 2.3°C and a range of 1 to 4°C, white at 50 cm depths the mean was 0.6°C with a range of -0.5°C to 2°C. Forest cover is generally abundant dwarf black spruce with some inclusions of alder. Bog birch is the primary and relatively abundant shrub with some labrador tea and cowberry. Horsetails and redtop are present but in relatively minor amounts. Sphagnum mounds are common on wetter sites. Mosses and lichens are relatively

abundant, including feathermoss, Aulacomium palustre, Tomenthypnum nitens, Cladina arbuscula, and Cladina alpestris.

Very poorly and poorly-drained mesic and humic organic soils

These soils of moderately- and well-decomposed organic matter, overlie glacial till and glaciolacustrine materials at depth. The landscape is generally composed of level fens with slightly drier phases on ridges and wetter phases with standing open water swales. These soils are relatively uncommon in the study area but some water quality data was obtained.

Due to standing water in some fens the ground temperature data is limited but on drier sites ice was contacted at 25 cm depth and on wetter sites water was found to a depth of 90 cm.

Vegetation on the slightly drier ridges consists of primarily tamarack with some scattered black spruce, white spruce and some willow. Bog birch is the major shrub. Sphagnum sp. mounds are found on the slightly drier sites giving the land a hummocky microtopography. In wetter sites, ponds of standing water are often found with sedges, cottongrass, some mosses, and some shrubs including bog birch, labrador tea, and willow. Reindeer mosses are found on hummocks in slightly drier areas of the fens.

Fibric organic soils

Cryic fibrisols are found generally on poorly to imperfectly-drained "peat plateau" or "palsa" landforms. These landforms are characteristic of the zone of discontinuous permafrost. Insulated against thawing by a thick organic mat which is only slightly decomposed, they are generally underlain by permafrost in the Mackenzie lowlands at 25 to 50 cm depth.

The major vegetative cover consist of reindeer moss hummocks with associated labrador tea. Sphagnum hummocks have crowberry and moorwart herbs on them. Black spruce are found scattered and stunted on outer edges of the bog with some seedlings invading it, bog birch and labrador tea are also present. Sedges and haircap moss are found in the depressions between hummocks.

From the foregoing discussion it can be seen that there are relationships amongst soils, vegetation communities and ground frost in the study area. As a result of climatic factors and the recent glacial history, various types of soil have developed under various types of vegetation communities. Some of the permafrost found in this zone may be fossilized ice (Pewe, 1966) protected by a thick, insulating organic mat or it may have formed in poorly drained regions under years of accumulation of insulating vegetation debris. Regardless of how the ice was formed, the present location of ground frost (perennially frozen or not) is highly correlated with the texture and drainage

of the soil and with the vegetation communities which are found protecting the ice from rapid and large temperature changes.

6.4 Study of ground subsidence on seismic lines and roads, Wrigley area

Recent mineral and petroleum exploration and discoveries in the Canadian north have lead to concern for the effects on the northern environment of developing and transporting these resources to urban centres in the south. The specific area under study forms a segment of the proposed oil and gas pipeline and Mackenzie highway corridor. This area is situated in the discontinuous permafrost zone (Brown, 1967), permafrost being defined as ground which has remained at less than 0°C for two or more years. Water content may vary thus there may or may not be special engineering problems. The frozen, ice-rich unconsolidated materials usually develop under poor internal drainage and, in the discontinuous zone, permafrost is formed under and protected by thick insulating layers of organic material.

This organic mat undergoes large seasonal fluctuations in its thermal properties which result in a negative heat budget. During summer, the peat surface becomes relatively dry with low thermal conductivity and diffusivity resulting in little heating of the ground and, conversely, in winter, the peat is relatively moist and has a high thermal conductivity and diffusivity which result in cooling of the ground. The overall effect of these large seasonal fluctuations in thermal properties is a negative heat budget which allows the underlying materials to remain

frozen. Once the insulating cover is removed the underlying ground will thaw and subsidence will occur if the frozen material is super-saturated. Since peat landforms are common along the proposed Mackenzie transportation corridor, a study of the effects of the removal of this cover for roads and pipelines is necessary.

Due to extensive petroleum and mineral exploration, the residual effects of clearing seismic lines are readily observable. The primary objective of this study is to document the amount of ground subsidence, the depth to ground frost, and the vegetation types on the disturbed and undisturbed portions on different seismic lines of different ages and different construction techniques. These observations will aid in describing the effects of seismic lines and roads on the environment of this particular region.

The study was conducted on "peat plateau" landforms which had been crossed by either a seismic line or a winter road. Once the sites were chosen a representative cross-sectional profile of each site was determined by laying a 30 metre tape measure across the cut line from the undisturbed material on one side of the cut to the undisturbed material on the opposite side. The heights of hummocks and depths to ground ice were taken at intervals along the tape measure and the depth to ice was determined with a calibrated probe. The cross-sectional profile

was plotted on with a vertical exaggeration of 5 or 10 times to show the natural undisturbed hummocks and depressions, the construction cut with subsequent subsidence, and the construction spoil at the sides of the cut. The vegetation found on the undisturbed sections was documented and compared with the regeneration or successional vegetation in the cut and on the spoil banks. From these observations conclusions were drawn concerning ground subsidence and vegetative regeneration.

Three different peat plateau sites were assessed; two were recent seismic lines (approximately 1970) and the third was an old abandoned winter road (greater than 10 years).

Seismic line near Lily Pad Lake (Unnamed on NTS maps)

This seismic line study site was located on a relatively dry peat plateau near a lily pad-covered lake. The line had been constructed recently (approximately, 1970) by bulldozing lightly over the organic mat so that only the tops of the organic hummocks were removed and pushed to the sides in a small windrow leaving patches of bare peat on much of the cut line (Figure 37). This method of construction caused relatively little destruction of the protective insulating organic mat and there was no evidence of ground subsidence on the seismic line itself (observed in mid-July). In areas where the seismic line cut across existing drainage channels there was evidence of

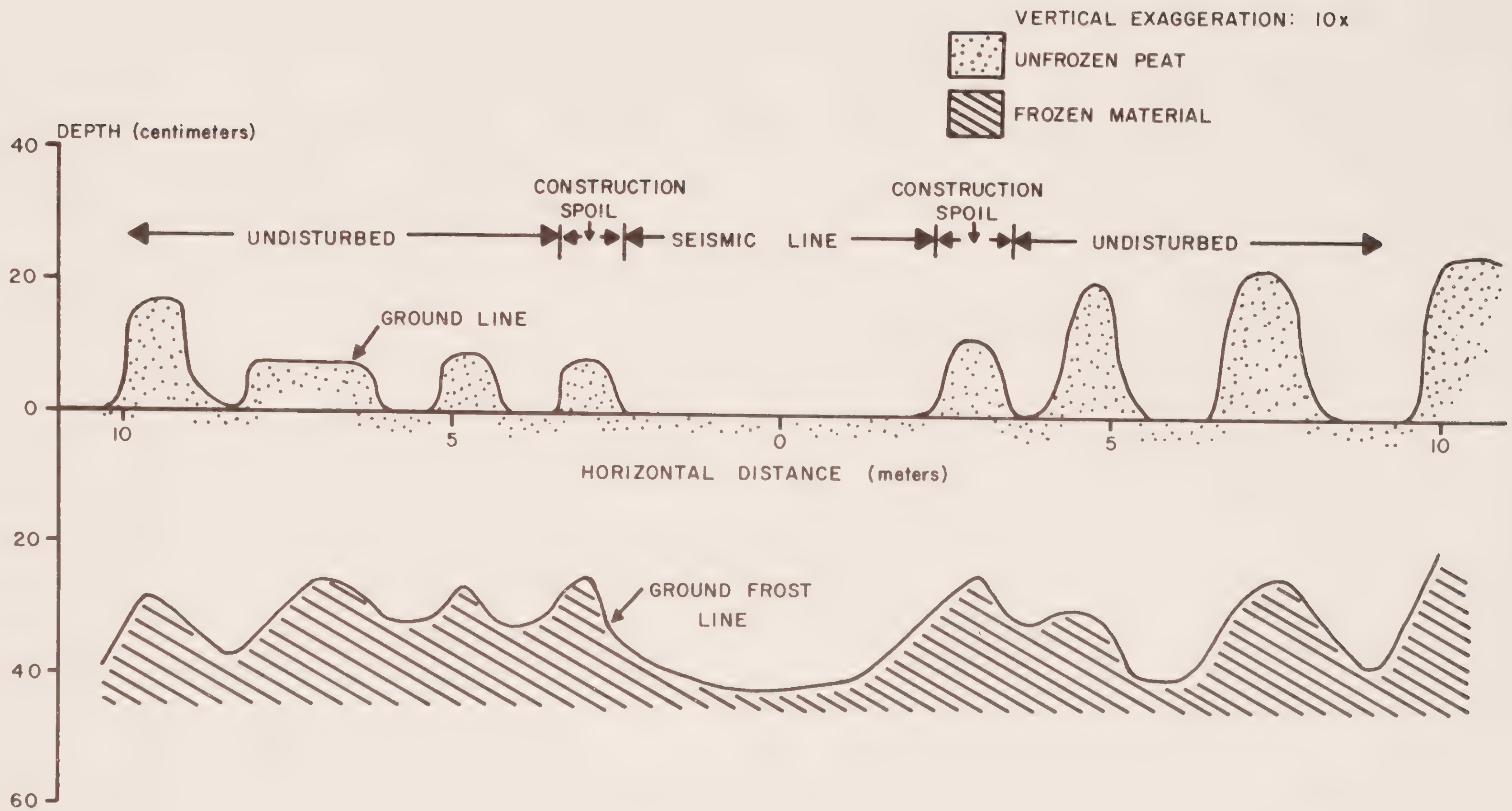

Figure 39. Ground subsidence of seismic line on peat plateau

Table 8: Vegetation of undisturbed zone of Lily Pad Lake seismic line

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m						
<10 m	x					Picea mariana
Shrubs						
>2 m						
1-2 m						
<1 m			x			Ledum decumbens, Myrica gale, Vaccinium vitis-idaea
Herbs	x					Rubus chamaemorus
Graminoids						
Sphagna		x				Sphagnum fuscum
Mosses		x				Dicranum sp
Lichens					x	Cladina alpestris, Cetraria cuculata

Table 9: Vegetation of disturbed zone of Lily Pad Lake seismic line

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m						
Shrubs >2 m						
1-2 m						
<1 m	x					_Ledum decumbens_, _Andromeda polifolia_, _Ledum groenlandicum_, _Betula papyrifera_, _Myrica gale_, _Empetrum nigrum_, _Vaccinium_ sp.
Herbs	x					_Rubus chamaemorus_
Graminoids						
Sphagna						
Mosses	x					_Polytrichum juniperinum_
Lichens		x				_Cetraria cuculata_, _Cladina arbuscula_, _Cladina alpestris_

relatively minor ground subsidence and thaw pocket formation.

The undisturbed zone of this site was covered primarily (75 to 100%) by hummocks of dry reindeer mosses, with some cracks in the cover (Table 8). Sphagnum hummocks of specifically _Sphagnum fuscum_ covered 5 to 25 percent of the area, with _Dicranum sp_. mosses and some lichens filling the depressions. Labrador tea and sweet gale were the primary medium shrubs, while cowberry and baked appleberry made up the major portion of the low shrub and herb layers. Although none were abundant scattered shrubby black spruce were found on the undisturbed site.

Regeneration on the disturbed zone appeared to be relatively rapid with hair cap moss invading the bare peat (Figure 38). _Cetraria cuculata_, _Cladina arbuscula_, and _Cladina alpestris_ were the major species present (approximately 25%) on the seismic line and are found primarily in the depressions. Shrubs, herbs and mosses occupied about 5 percent of the cut line, labrador tea was the major low shrub, baked appleberry the major herb, and hair cap moss the major moss. Other species of minor abundance include bog birch, vacciniums, sweet gale, crowberry and moorwart. The vegetative cover of the depressions was little disturbed by the construction of the seismic line and is therefore similar to that in depressions in the undisturbed zone (Table 9).

The plot of the cross-sectional profile through the undisturbed, disturbed, undisturbed zones of the seismic line in July give very little evidence of ground subsidence under this seismic line (Figure 39).

Seismic line near Ochre River (South Arm) east of Cap Mountain

The second seismic line studied was situated on a slightly wetter peat plateau in a depressional area near the south arm of the Ochre River east of Cap Mountain. This seismic line was cut deeper (1969 or 1970) into the organic mat thus removing more of the insulating cover and creating more ground subsidence under the cut line.

A cross-sectional profile of the microtopography and depth to the frozen ground was determined and plotted (Figure 40). Vegetation species and abundance were also recorded for the undisturbed (Table 10) and disturbed (Tables 11 and 12) zones of the cross-section.

The exact depth of the original cut into the organic mat is unknown, but can be estimated from the graph. The depth of ground subsidence was estimated at between 10 and 20 centimetres of subsidence below the estimated depth of the original cut. This estimation was made on the assumption that the original ground surface had a micro-topography similar to that of the undisturbed zone, that the spoil from the cut line was

placed on top of this surface at the sides of the cut and that settling and decomposition of the spoil was negligible. The seismic line was pitted along its length by thaw pockets many of which were holding water in July (Figure 41). These thaw pockets gave the cut line a rolling microtopography of depressions and hummocks.

The characteristic undisturbed vegetation was a moss-lichen association with minor inclusions of scrub trees, low shrubs, herbs, and graminoids (Figure 42). <u>Dicranum sp</u>. hair cap and feathermosses were the major mosses associated with the lichens, <u>Cladina alpestris</u>, <u>Cladina mitis</u> and <u>Cetraria cuculata</u> between them making up more than half of the ground cover. Sedges made up 5 to 25 percent of the ground cover and 1 to 5 percent of the area was supporting small black spruce and some tamarack with labrador tea and bog birch were the low shrubs, while the herb layer comprised predominantly baked appleberry. Hummocks were present (less than 1 percent).

Regeneration of vegetation on the construction spoil was limited to low shrubs, herbs, graminoids, mosses, and lichens, all in small amounts. Labrador tea, baked appleberry, sedges, hair cap moss, and <u>Cladina mitis</u> were the commonest species.

Regeneration on the seismic line cut itself was slightly different in species composition compared with that of

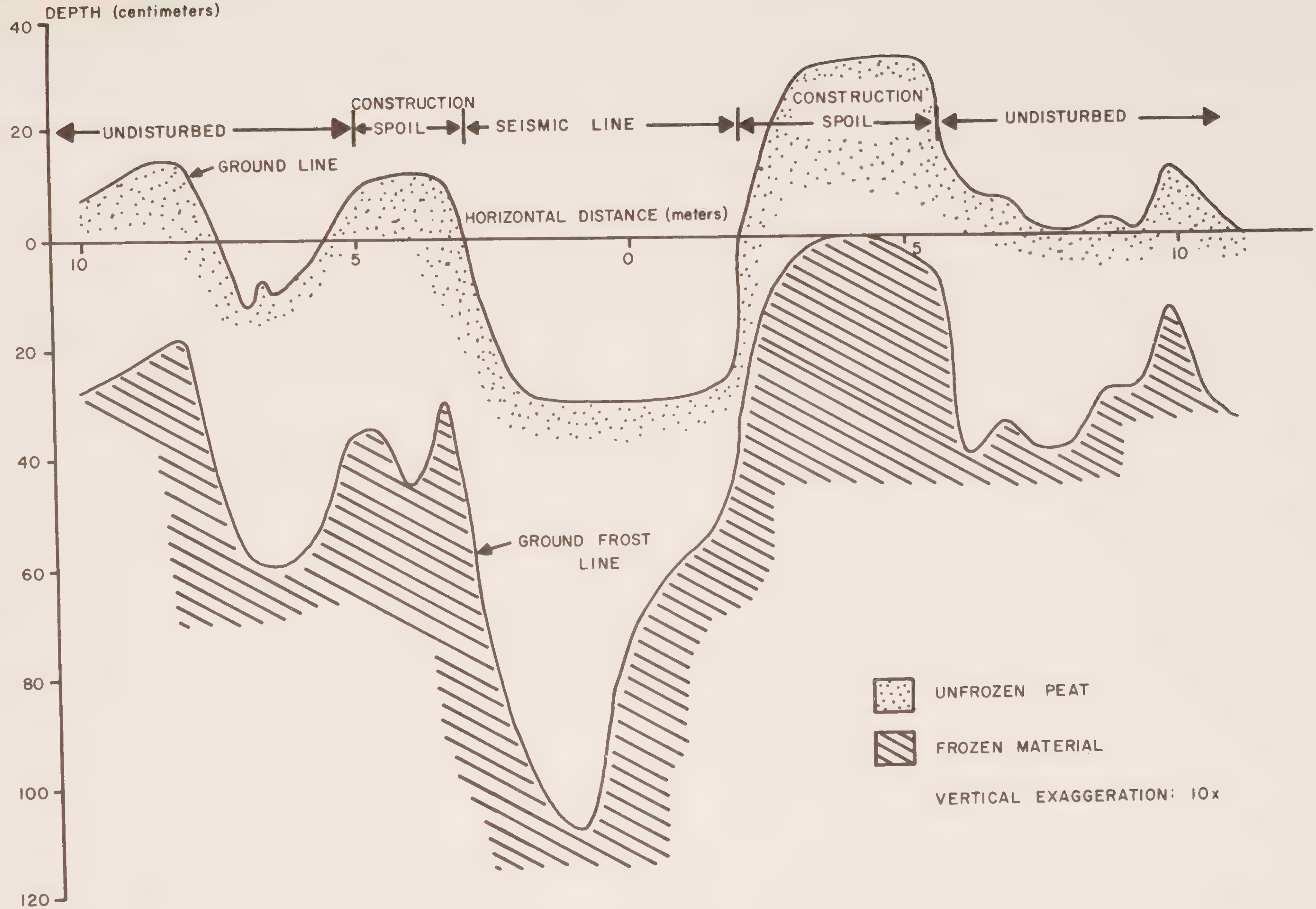

Figure 40. Ground subsidence of seismic line (1070 winter), east of Cap Mountain

Table 10: Vegetation on undisturbed zone of seismic line, near Ochre River

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m	x					*Picea mariana*, *Larix laricina*
Shrubs >2 m						
1-2 m						
<1 m		x				*Ledum groenlandicum*, *Betula glandulosa*, *Vaccinium* spp., *Salix* sp., *Empetrum nigrum*
Herbs	x					*Rubus chamaemorus*, *Andromeda polifolia*
Graminoids		x				*Carex* sp., *Agrostis alba*
Sphagna						
Mosses			x			*Dicranum* sp., *Polytrichum juniperinum*, *Hylocomium splendens*
Lichens		x				*Cladina alpestris*, *Cladina arbuscula*, *Cetraria cuculata*

Table 11: Vegetation on construction spoil zone of seismic line near Ochre River

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m						
Shrubs >2 m						
1-2 m						
<1 m	x					*Ledum groenlandicum*, *Vaccinium* spp., *Salix* sp.
Herbs	x					*Rubus chaemaemorus*
Graminoids	x					*Carex* spp., *Agrostis alba*
Sphagna						
Mosses	x					*Polytrichum juniperinum*
Lichens	x					*Cladina arbuscula*

Table 12: Vegetation of disturbed zone of seismic line near Ochre River

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m						
Shrubs >2 m						
1-2 m						
<1 m	x					Vaccinium spp., Ledum groenlandicum
Herbs	x					Rubus chamaemorus
Graminoids		x				Eriophorum spissum, Carex spp., Agrostis alba
Sphagna						
Mosses		x				Polytrichum juniperinum
Lichens	x					Cladina alpestrus, Cladina Rangiferina, Cladina arbuscula Cetraria cuculata

the spoil heap because of the greater wetness of the depression of the cut line due to thaw pocket development. Vacciniums were the major low shrub regeneration species with labrador tea and baked appleberry being of lesser importance. Cotton grass was the major graminoid with sedges next in abundance. Hair cap moss and reindeer moss were the primary moss and lichen species respectively.

Generally, recovery of the vegetative cover on the disturbed zone was slow with a few species predominating in the primary regeneration. Ground subsidence due to removal of the insulating organic mat was evident here.

Abandoned winter road, east end of study area

The third site for which detailed observations were made was situated at the most eastern extent of the study area on an abandoned winter road. This road was constructed before 1950 and was abandoned within the past decade. Ground subsidence along this road cut has been considerable. As with the other seismic line descriptions, a cross-sectional profile of the microtopography and depth to frozen ground was plotted (Figure 43). From the graph and on-site observations there was no evidence of construction spoil remaining. There was a great deal of evidence of thaw pocket formation and ground subsidence along the length of the road. Depressions up to 100 centimetres deep, and sometimes

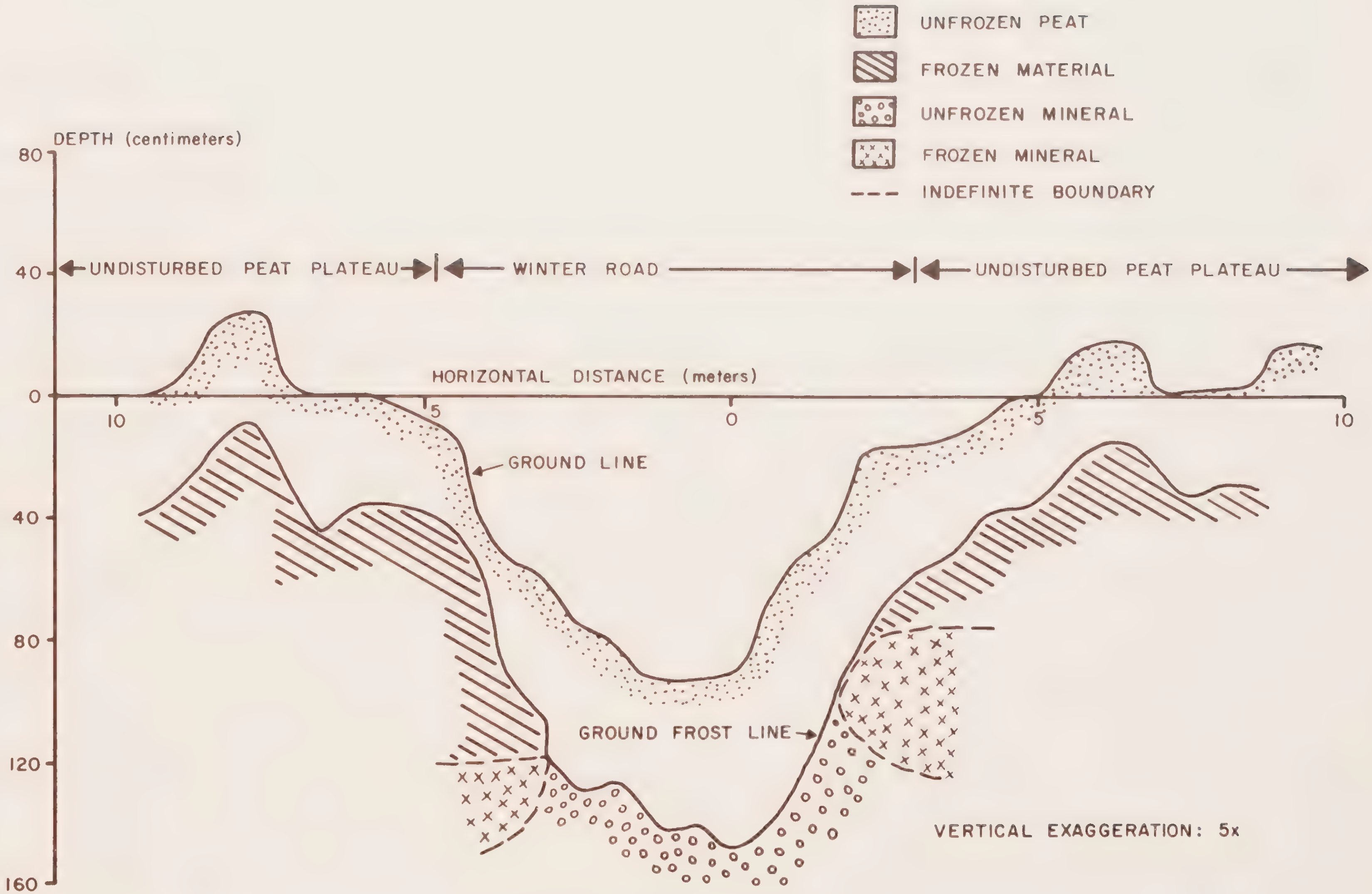

Figure 43. Ground subsidence on old winter road, east of Cap Mountain

greater, were found along the length of the road as it crossed this wet peat plateau. Unfrozen mineral soil was found in the depressions under the thawed organic mat. The difference in depth to mineral soil below undisturbed ground and the depth to mineral soil below the road line was considerable (70 to 80 centimetres), presumably due to thawing in the mineral material causing the mineral and peat strata to subside. This would be expected if the ground ice comprised more than the pore volume of the sediment.

With the removal of the insulating organic mat, the active layer increased in thickness causing ice lenses in the mineral soil to thaw, with consequent subsidence. This illustrates the heat bulb effect of the removal of vegetative cover and surface organic mats in the construction of roads, seismic lines, or buildings, (Brown 1963). In this case, the mineral material directly underlying the depression of the road cut appeared to be unfrozen although there was a frozen stratum at the interface of organic and mineral strata. At the edges, the frozen organic material was easily broken through and the mineral material also appeared to be unfrozen thus suggesting a bulb-like thawed area underlying the road cut and extending underneath the adjacent permafrost. The area and extent of this bulb-like thaw pocket was not determined due to lack of time and suitable equipment.

The characteristic vegetation of the undisturbed zone (Table

13) of this cross-sectional profile is primarily a low shrub, sphagnum, lichen association (Figure 44). Stunted black spruce predominates in the tree layer comprising approximately 25 percent of the stratum. There was evidence of a recent ground fire on the charred trees but their growth and the growth of the moss and lichen cover did not appear affected. Approximately 50 percent of the total ground cover is sphagnum hummocks with Cladina spp. in the depressions and invading the hummocks as they grow larger and drier. Labrador tea and small bog cranberry are the major low shrubs occupying about 50 percent of the low shrub layer. Sphagnum fuscum is predominant on the hummocks with no evidence of other mosses. Reindeer mosses are the major lichens occupying approximately 50 percent of their vegetative layer. Baked appleberry, the predominant herb, occupies 5 to 25 percent of the area.

Regeneration of the disturbed cut is due primarily to Sphagnum fuscum hummocks (Table 14). These hummocks also had hair cap moss on them which was invading the depressions. Graminoids are also found on the hummocks, sedges predominate in the depressions, covering 50 percent of the area, and occur on the following hummocks also (Figure 45). Labrador tea was the predominant low shrub covering 25 to 50 percent of the drier parts of the site. Herbs were found on less than 5 percent of the area, with baked appleberry predominating. A few small black

Table 13: Vegetation on undisturbed zone of winter road

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						Shagnum hummocks with cladonia in depressions and invading hummocks.
>20 m						
10-20 m						
<10 m			x			*Picea mariana*
Shrubs						
>2 m						
1-2 m						
<1 m				x		*Ledum decumbens*, *Oxycoccus microcarpus*, *Ledum groenlandicum*, *Andromeda polifolia*, *Chamaedaphne calyculata*
Herbs		x				*Rubus chamaemorus*
Graminoids						
Sphagna				x		*Sphagnum fuscum*
Mosses						
Lichens				x		*Cladina alpestrus*, *Cladina arbuscula*, *Cladina rangiferina*, *Cetraria cuculata*

Table 14: Vegetation of disturbed zone of winter road

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						Polytrichum invading depressions; Polytrichum and graminoids on Sphagnum hummocks.
>20 m						
10-20 m						
<10 m	x					Picea mariana
Shrubs						
>2 m						
1-2 m						
<1 m			x			Ledum groenlandicum, Ledum decumbens, Vaccinium spp., Andromeda polifolia, Oxycoccus microcarpus, Empetrum nigrum
Herbs	x					Rubus chamaemorus, Drosera rotundifolia, Smilacina trifolia
Graminoids				x		Carex spp., Eriophorum spissum
Sphagna			x			Sphagnum fuscum
Mosses		x				Polytrichum juniperinum, Dicranum undulatum
Lichens	x					Cladina arbuscula, Cladina alpestris, Cetraria cuculata.

spruce seedlings were found on the road.

The increasing vegetation mat regenerating on the road cut suggests that the protective insulating cover will eventually regenerate to such an extent as to reduce the extent of the active layer and eliminate further ground subsidence under the road cut. However, the rate of recovery is very slow.

Miscellaneous seismic lines

Seismic line construction may have greater or less impact on specific sites depending on the texture of the underlying material, the landform, the construction techniques used and the amount of traffic over the seismic line during different seasons of the year.

A recent seismic line on a 5 to 10 percent slope was observed to have a stream flowing along it for several hundred metres (Figure 46). The result of the seismic line cutting across natural drainage lines was to divert the water from the natural drainage channel onto the seismic cut where, the vegetation having been removed, there was no resistance to the flow of the stream and serious erosion was resulting (Figure 47).

In some areas where summer mineral exploration was being conducted some seismic lines were used as roads for all-terrain vehicles. As a result of this traffic deep ruts were formed in the soil (Figure 48). The removal of vegetation for construction

of the seismic line initiated deepening of the active layer. This was aggravated by heavy vehicular traffic which appeared to compact the materials and thus increase the depth of the active layer. The increased thawing trend caused deep pools of standing water to collect in ruts on the road (Figure 49). This extreme disturbance and the subsequent local ponding will delay vegetative regeneration considerably and water standing in track ruts and local depressions will enhance the heat-bulb effect. This will cause further deepening of the active layer which, in extreme cases, could result in marsh, swamp or thaw lake formation (Ferrians, Kachadoorian, and Greene, 1969). In less extreme cases this disturbance will result in very slow vegetative regeneration with possible fen development as a transition zone between the state of severe disturbance and the climax vegetative stage.

Horn plateau, Fort Simpson area, N.W.T.

In 1971, the group studied soils, vegetation and landforms in the Fort Simpson area. To observe the effects of the removal of the insulating organic mat, two trenches were dug in peat plateau landforms on the Horn plateau. These trenches were 30 cm wide, 1 to 3 m long and exposed the ice underlying the organic mat. They were observed, recorded and left open for future reference. In July 1972 the trenches were re-examined and changes in them recorded.

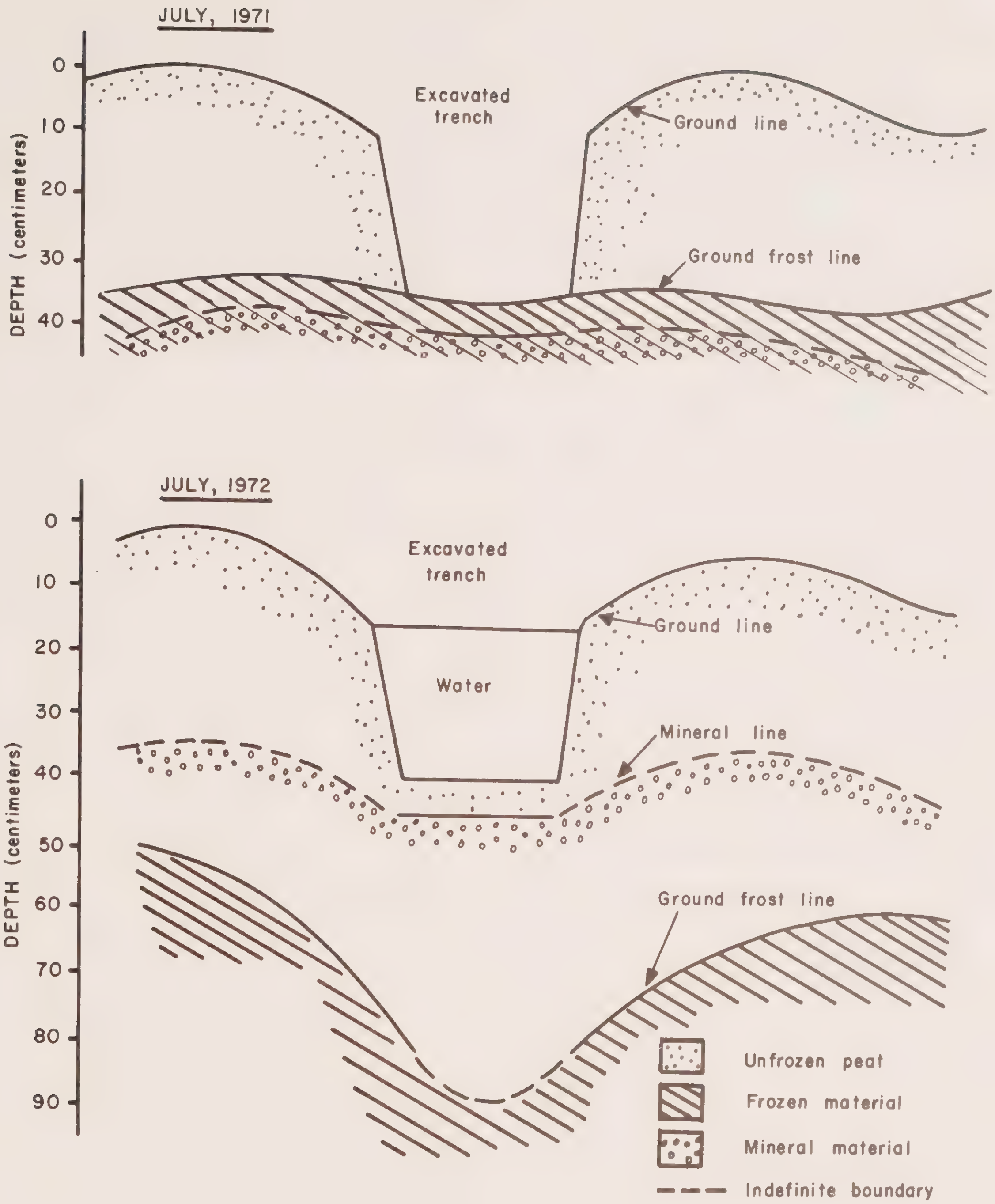

Figure 50. Illustration of ground subsidence in black spruce forest area on the Horn Plateau, N.W.T. over a span of one year following disturbance.

The first trench was near a small lake, arbitrarily named "Beach Lake". This site was a sphagnum moss - lichen - black spruce vegetation association (Figure 50) of a peat plateau landform. Sphagnum hummocks covered approximately 50 percent of the area; reindeer moss and feathermosses were invading the depressions and some of the hummocks. Labrador tea, and other low shrubs were common in the depressions. The depth to ice in 1971 was 25 to 30 cm. The depth to ice of this same trench in July 1972 was greater than 60 cm and there was approximately 25 cm of water lying in it (Figure 51). Measurements taken 2 m from the trench on either side showed the depth to ice to be 30 to 60 cm. While at distances greater than 2 m from the trench, the ice was 25 to 30 cm deep (Figure 52). Some ground subsidence was noted along the trench. Sandy mineral material, underlay the organic mat at approximately 30 cm.

The second trench was dug on a polygonal bog on the Horn Plateau which was dominated by reindeer mosses and dwarf shrubs. The polygons (Tarnocai 1970) on the bog are outlined by fissures or channels of variable width. These fissures are formed by development of almost pure ice wedges which form when the underlying permafrost contracts and forms fissures on the surface. These fissures then fill with water in spring and freeze in winter (Pewe, 1966). They may also be fossilized ice wedges which have been exposed by further contraction of the underlying permafrost.

Some of the channels are moss filled, some have standing water and sedges and some are bare organic matter. Presumably those fissures which are filled with bare organic matter are more recent ice wedge eruptions or exposures.

The trench was dug in 1971 to cross a bare peat-filled channel from the *Cladonia* hummocks on one side across the channel into the *Cladonia* hummocks opposite. In the preliminary cut (1971), ice was found at 30 cm depth under the organic mat (Figure 53) and at the bottom of the fissure under bare peat at approximately 40 cm from the top of the fissure. The miniature fen which was present at the time of exposure in 1971 had expanded by approximately 4 m a year later. In the open pits the organic layer thawed to depths of 55 to 60 cm, with no free water standing in the pits. The ice wedge was melted to a depth of 60 or 65 cm (Figure 53).

The protective insulating vegetative cover of the undisturbed areas of the peat polygons is distinctive. The hummocky surface supports dwarf shrubs and an almost complete cover of lichen giving the surface a very high albedo. The species present include labrador tea, crowberry and reindeer mosses. Trees are generally confined to fissures and edges and are generally very small (< 1 metre); those found on the edges are the larger.

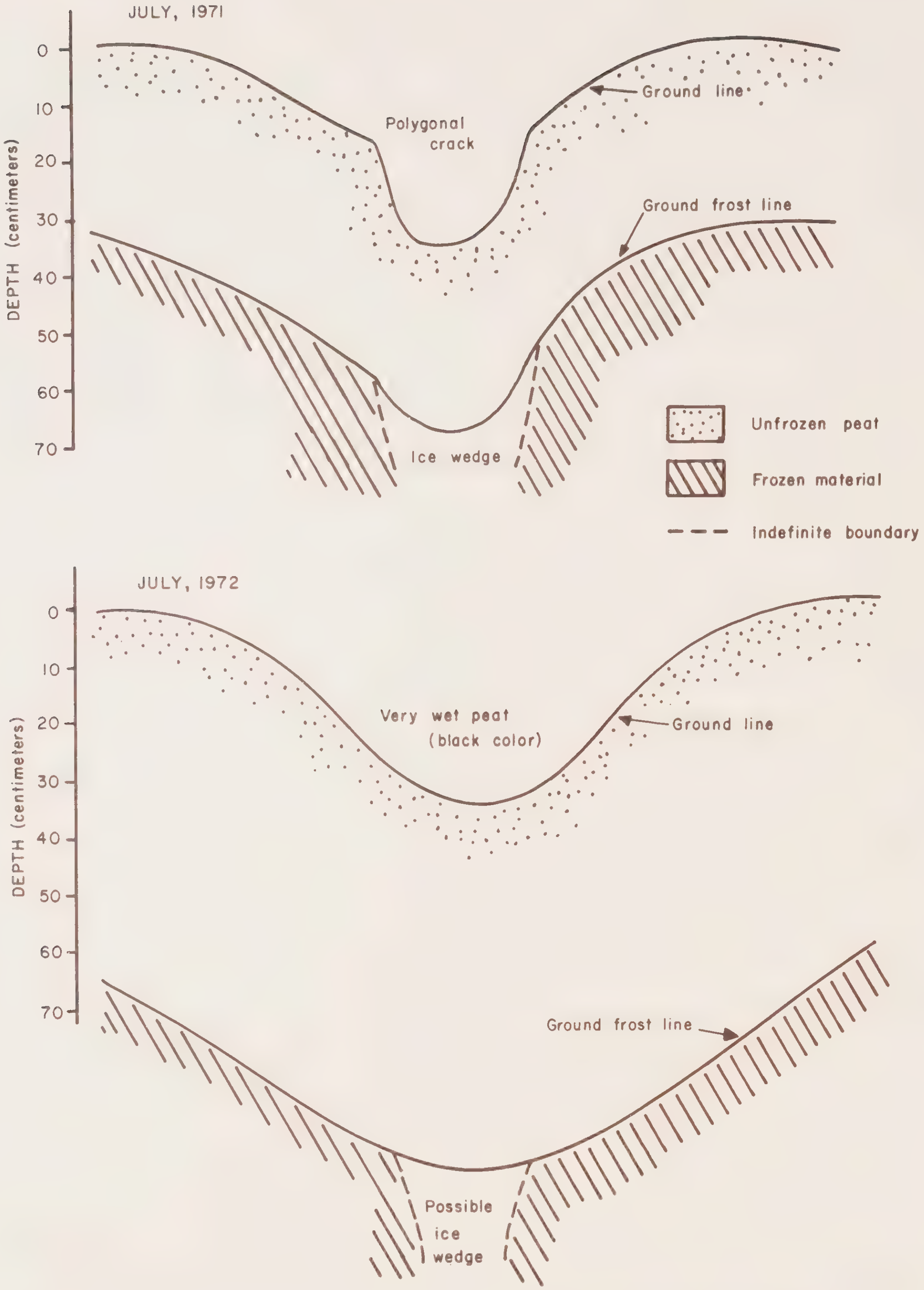

Figure 53. Illustration of ground subsidence in polygonal bog area on the Horn Plateau, N.W.T. - over a span of one year following disturbance.

From these very general observations it can be seen that even minor land use disturbances which expose the permafrost can cause extensive alteration of the ecosystem.

River bank slumping

Not all disturbances of the land surface are anthropogenic. Flooding of streams and rivers in spring, in this region, causes significant bank erosion. As the water level subsides, fresh materials are exposed to thawing and, if this freshly exposed material has a high ice content, it becomes super-saturated as the ice melts and slumps or collapses. Even in cases where ice is not present in sufficient amounts to cause slumping of relatively unstable slopes as it thaws the effect of the high water of the river saturating its own banks may cause the bank to slump or cave-in (Holmes, 1965).

River bank slumps are common throughout the Mackenzie Valley. An example was found on a minor stream flowing eastward into the Mackenzie River (Figure 54).

This study was conducted in order to indicate, to a limited extent, the degree and amount of ground subsidence which may occur as a result of the removal of the vegetative cover or organic mat covering the soil on selected sites in the Mackenzie River Valley, N.W.T. Five sites were studied in detail. Three sites documented in detail were cut lines which had been constructed

across peat plateau landforms. These sites were of slightly different water content, were constructed using slightly different techniques and had slightly different land use histories but comparison between them was found to be relevant and significant. Two sites were disturbed by the construction of trenches in July, 1971, on the Horn Plateau near Fort Simpson, in order to study the effects of this well-dated, short-term disturbance on the environment.

Those cut lines which had been constructed across peat plateaux had varying effects on the depth of ground ice and ground subsidence by July, 1972. The first seismic line discussed, near Lily Pad Lake, was recently constructed (within past 3 years). Only the tops of the *Sphagnum* and *Cladonia* hummocks were bulldozed off so that the line was level but there was little disturbance of the insulating organic mat. There was essentially no evidence of either increased depth of the active layer or of ground subsidence. The second peat plateau cut line, near the south arm of the Ochre River, was approximately the same age as the first but was constructed by cutting deeply into the organic mat and pushing the spoil into a windrow at the side of the cut. In this case the amount of ground subsidence was substantial and evidence of thaw pockets holding standing water was very obvious. The third peat plateau disturbed site was an abandoned winter road. This road, although used only in the winter and abandoned for the past

decade, showed considerable ground subsidence. Vegetative regeneration was filling in the cut line and healing some of the scars of disturbance but the process is slow. All evidence of construction spoil had disappeared. This site, although abandoned, is recovering only very slowly.

The trenches dug in 1971 on the Horn Plateau near Fort Simpson, N.W.T., showed very graphic results of minor disturbance. One dug on a peat plateau and the other dug on a polygonal peat bog, they showed how exposure of the frozen ground underlying the insulating organic mat results on ground subsidence and fen formation by increasing the depth of the active layer of the soil.

Miscellaneous seismic lines were observed from the air. They indicate a) the erosion caused by seismic lines cutting through and disturbing natural drainage channels; b) the effects of repeated all-terrain vehicle traffic over seismic lines not constructed to withstand heavy vehicle traffic during the summer months when the ground is thawed; and c) the effects of natural agents, such as flooding rivers and streams which cut away and super-saturate their own banks causing slumping and possibly further flooding.

The foregoing study recorded some detailed and general observation of the effects of land use or natural disturbances on the actively freezing and thawing (surface) soil layers. Generally, the removal of the natural vegetative cover and the underlying

organic mat resulted in ground subsidence of varying degree depending on the severity of the disturbance. In some cases little damage was done, while in other cases fen development was initiated, or serious erosion was observed. This reconnaissance study shows general trends of the results of those land use practices, specifically seismic line and winter road construction, which are practised in the Mackenzie River Valley today. These practices may cause serious damage to an environment which, mainly because of climatic limitations, is very slow to recover from disturbance. The results of disturbance are usually intensified and extended by natural processes before they begin to regenerate and revert to equilibrium with the existing environmental conditions.

6.5 Air Photography for Resources Surveys

Comments on Available Air Photography

Black and white panchromatic.

All of the mapping of soil, vegetation and landform patterns was completed on black and white, panchromatic air photography. The shortcomings of the available photography were related to the age of the photos, different scales, and different seasons. The airphotos used for the Wrigley study area ranged in age from 1950 exposure dates to 1971 exposure dates. The scale of the airphotos available ranged from approximately 1:40,000 to 1:60,000. Scale changes between adjacent flight lines led to time

losses and reduced efficiency during the survey program. Seasonal variation between flight lines, producing quite different tonal patterns, is another example of the kinds of problems that could be avoided if new air photography was available for the entire area prior to field work.

Colour Infrared

A few flight lines of recent colour infrared air photography were available for examination this year (flight line A-30366), but these were inadequate, and only emphasized the need for well-planned and co-ordinated programs for the acquisition of new photography. These colour infrared photos were taken on August 29, 1971, much too late in the growing season to be of maximum use in identifying with confidence the vegetation component of the landscape (and in these regions the vegetation patterns are most useful as an indicator of the associated types of terrain).

Examples of the specific limitations of the colour infrared photography are:

(a) Many of the prints are poorly exposed and are dark.

(b) Most of the sedge, grass and shrub vegetation of the fens appears as "dead" vegetation because of the late August exposure time. Colour infrared slides taken during July suggest that the "fen" types of organic terrain should be readily identifiable and

should register as a bright red to pinkish colour on the infrared film.

(c) Again, because of the late August exposure, the tones of the stands of deciduous species such as aspen are highly variable due to patches of trees in leaf fall, stands in the process of fall colour changes, and patches of trees that have not changed. The deciduous stands, therefore, range through white to pink to darker tones on the same photo.

The thermokarst peat plateau organic terrain units show up quite well on the colour infrared and feature a relatively distinctive pattern of tones. However, these areas can be identified and mapped without much difficulty (once the pattern is established and checked with some ground control) on black and white photography.

This year's airphoto interpretation confirmed last year's conclusions that late spring or early summer air photography is better than late summer photography for mapping of soil, vegetation and landform patterns in this region. For example, the older photography exposed in June 1950 (flight lines A-127000 and A-12610) is superior to the recent photography of August 18, 1971 (flight line A-22426). Air photography taken in mid-July 1964 (flight A-18310) was fair to good, but not quite as useful as the June 1950 photography. Airphotos at a scale of 1:60,000 to

1:70,000 were judged to be the most useful base for interpretation of landscape components.

Although colour air photos of the landscapes in the Mackenzie corridor have not been available to date, indications are that this type of photography, taken in June or July, might be the best source of information to aid in the mapping of the terrain and landscape patterns of the region.

6.6. Clay Mineralogy of Selected Geologic Materials and Soils

A part of the program undertaken in the Wrigley area was the characterization of soil materials. This program was largely conducted by Dr. N.W. Rutter of the Geological Survey of Canada. One of the parameters of importance in characterizing earth materials is the mineralogy of the clay fraction which strongly affects the physical and chemical properties of soil.

Soil samples were collected by both G.S.C. and U.B.C. personnel for clay mineral identification. The samples were air-dried, crushed and fractionated by sieving and centrifuge techniques. The clay-sized separates were subjected to oriented slide X-ray diffraction analysis using Cu K radiation.

The samples collected by U.B.C. personnel consisted of horizons within the soil as well as parent materials (Table 15). The second table reports on the results of the determinations conducted on G.S.C. samples. The G.S.C. samples comprise parent

Table 15. X-ray identification of minerals present in the clay fraction (< 2u) of some Wrigley soils.

Geologic Material	Soil Type	Horizon	Dominant Minerals* in Clay Fraction	Laboratory No.
lacustrine plain	Orthic Gray Luvisol	BC	Vm Qtz Kt It Vm-It	3
		Cca	Vm Kt Qtz It	4
drumlinized till	Degraded Eutric Brunisol	BC	Vm Kt Qtz Mt Vm-It	12
		C	Vm Kt Qtz It	13
eroded till plain	Degraded Eutric Brunisol	Bm1	Vm Kt Cht It Qtz Vm-It-Cht	23
		Bm2	Vm Kt It Qtz Vm-It	24
		Cca	Vm Kt It Qtz	25
alluvial plain	Degraded Dystric Brunisol	Bm	Vm Kt It Qtz Vm-It	33
		BC	Vm Kt Qtz Vm-It	34
		C	Vm Kt It Qtz	36
till plain	Degraded Dystric Brunisol	BC	Vm Kt It Qtz Vm-It	39
		C	Vm Cht Kt It Qtz Vm-It	40
till complex	Degraded Dystric Brunisol	Bm	Vm Kt Cht It Qtz Vm-It	42
		BC	Vm Kt It Qtz Vm-It	43
		C	Vm Kt Qtz Cht It	44
sandstone and quartzite bedrock	Lithic Degraded Dystric Brunisol	Bm	Vm Kt It Qtz Vm-It	48
		BC	Vm Kt It Mt Cht Qtz Vm-It	49
		C	Vm Kt It Cht Qtz Vm-It	50
till over dolomite/limestone bedrock		C	Vm Kt Cht It Qtz	76
glacial drift material on shale bedrock	Alpine Dystric Brunisol	Bm	It Kt Qtz	91
		C	Vm It Kt Qtz	92

Geologic Material	Soil Type	Horizon	Dominant Minerals* in Clay Fraction	Laboratory No.
shale bedrock	Alpine Dystric	Bm	It Kt Qtz	104
	Brunisol	C	It Kt Qtz	105
limestone/dolomite	Alpine Eutric	Bm	Mt Cht Kt It Qtz	107
bedrock	Brunisol	BC	Vm Kt It Qtz	108
		Cca	Vm Kt It Qtz	109
drumlinized	Peaty Orthic	Bg	Vm Kt It Qtz	129
till plain	Humic Gleysol	C	Vm Kt It Qtz	130
outwash; esker	Degraded Eutric	Bm	Vm It Qtz	133
and esker	Brunisol	BC	Vm It Qtz	134
complex		Cca	Vm It Qtz	135
lacustrine over	Humic Eluviated	Btg	Vm It Kt Qtz	143
till	Glysol	Cgca	Vm It Kt Qtz	144
recent	Cumulic	C1	Vm It Kt Qtz Vm-It	156
alluvium	Regosol	C2	Vm It Kt Qtz Vm-It	157

*Listed in decreasing order of abundance.

Cht = Chlorite
It = Illite
Kt = Kaolinite
Mt = Montmorillonite
Vm = Vermiculite
Qtz = Quartz

Table 16. X-ray identification of minerals present in the clay fraction (< 2u) of some glacial till deposits (G.S.C. samples).

Sample Number	Dominant Minerals in Clay Fraction*
ANB - 2	It Vm Kt Qtz
ANB - 3	It Vm Kt Qtz Fspr
ANB - 4	It Vm Kt Qtz Fspr Mt
ANB - 5	Vm It Qtz Fspr
ANB - 6	It Vm Kt Qtz Mt
ANB - 7	It Vm Kt Qtz
ANB - 8	It Vm Mt Kt Qtz
ANB - 9	It Vm Kt Qtz
ANB - 10	It Vm Kt Qtz
A145	It Vm Cht Kt Qtz
A58	Mt It Cht Qtz

*Listed in decreasing order of abundance.

Cht = chlorite

Fspr = feldspar

It = illite

Kt = kaolinite

Mt = montmorillonite

Vm = vermiculite

Qtz = quartz

material or geologic material only (Table 16).

The clay mineralogy of the soil samples (Table 15) demonstrates that vermiculite is the dominant clay mineral found in the Wrigley area. This relationship is found for all geologic materials sampled. The next most significant minerals are kaolinite and illite. Montmorillonite and chlorite are found only sporadically and mainly in soil horizons near the soil surface which have experienced a more active weathering and pedogenic regime. This is exemplified by the presence of inter-stratified minerals such as vermiculite and chlorite (Vm - Cht). Fine-grained quartz appears in all samples. The results indicate a very heterogeneous suite of clay minerals with little evidence of swelling clays except in base-rich areas enriched with limestone or dolomite. In general, the clay minerals are little weathered and appear to reflect the original geologic material from which the deposits have been derived. Some of the mineral suites indicate the possibility of lithologic discontinuities especially on materials of fluvial, glacio-fluvial or alpine drift origins.

The X-ray diffraction identification of clay minerals on the samples collected by the G.S.C. (Table 16) are dominated by illite and vermiculite in about equal proportions. Only one sample (A58) had a large component of swelling clay (montmorillcnite). In general the clay mineralogy showed a heterogeneous mixture of clay minerals and generally low amounts of swelling clays.

The results reported herein are exploratory only and should be interpreted in conjunction with the analyses on grain size distribution, Atterberg Limits and other data collected by the G.S.C. In this manner more specific interpretations will be possible regarding terrain utilization and sensitivity as well as other soil engineering problems.

7. DISCUSSION

The program conducted in 1972 was similar to the study carried out in the Fort Simpson area in 1971. The major differences were that the U.B.C. field party worked in much closer association with the G.S.C. field party and that the area studied in 1972 had a greater diversity of terrain types than was encountered in the Fort Simpson study. The results of both the 1971 and 1972 programs are a part of an interdisciplinary and multidisciplinary study involving not only U.B.C. and G.S.C. but also other federal government agencies (Strang, 1972). The studies reported herein form an integral part of the overall program and must be interpreted in that light.

The results reported are oriented mainly towards appreciation of the physical environmental parameters found in the region. These results should aid as background information for derivative maps, analysis of critical or sensitive areas and base-line information regarding vegetative regeneration. More specifically, the U.B.C. contribution yields additional ground truth to the reconnaissance mapping of surficial geologic materials carried out by the G.S.C.

In the Wrigley area, few studies have been conducted that attempt to integrate environmental factors. Most of the work in the discontinuous permafrost zone has been short-term with little opportunity to examine environmental processes. Further north, studies have been carried out and are currently in progress

(Bliss, 1970; Bliss and Wein, 1972; Brown and Johnston, 1964; Brown, 1965a, 1965b; Day, 1968; Day and Rice, 1964; Mackay, 1963; Mackay, 1966; Mackay, 1967; Mackay, 1970; ALUR Reports 1970-71 and 71-72). Fewer programs have been conducted south of the general area of Wrigley within the Mackenzie Valley.

This report should serve as an aid in the environmental assessment of the development of a transport corridors with highway, access roads, pipelines, seismic operations and so on. In addition, the studies of the interrelationships among soils, vegetation and landforms coupled with chemical and physical data on samples collected will be useful for purposes of environmental manipulation and reclamation following land disturbances. The fire history in the area and the resultant mosaic of vegetative cover mask other environmental influences and so reliance has to be placed on soils, as they integrate the environmental factors, in order to obtain meaningful interpretations regarding wildlife habitat, natural vegetative productivity, groundfrost dynamics, slumping, drainage and re-vegetation. The analytical data presented here should be of prime interest not only in assessing the present environmental factors but also in predicting problems and helping to develop solutions to problems as development occurs.

8. CONCLUSIONS

Although only limited field work was possible and research was carried out only during the summer months, several conclusions are drawn. These include:

1. The region around Wrigley, N.W.T. lies between areas such as Fort Simpson to the south, with large areas of alluvial and a variety of organic terrain, and areas further north where more typical arctic terrain prevails with ice-cored peat polygons becoming more abundant. The region is thus characterized as transitional with respect to ground ice conditions and dynamics.

2. The Mackenzie River Valley in this region is rather narrow being confined between the Mackenzie and Franklin Mountains. The valley itself is dominated largely by silty and clay-rich soils of lacustrine and alluvial origin. These soils, in addition to having variable ice contents and insulating surface accumulations of organic matter, are generally aggregate-poor. In addition, the fine-textured character of the soils lends itself to potential and existing problems of erosion especially along river banks and other exposures.

3. Examination of the terrain by ground traverse and air photographs shows the extensive, repeated fire history of the area with the resultant vegetative mosaic of varying successional stages. This fire history has affected the thermal properties of the surface soils and consequently the distribution and seasonal dynamics of permafrost. Some areas have escaped recent fires as

is shown by relatively pure stands of black spruce and white spruce.

4. Extensive areas of fine-textured poorly-drained soils are dominant in the region. These soils must be managed carefully if harmful effects are to be avoided.

5. There is rather poorly-defined surface drainage in much of the flatter terrain in the region characterized largely by gleysolic and organic soils. These areas are reservoirs of water and should be carefully managed to minimize water diversion, ponding or excessive draining which may cause increased run-off in the spring and larger freshets.

6. Even small water channels cannot be ignored in engineering design. Extensive alluvial deposits and damage to riparian vegetation show what harm may be caused by flooding.

7. Ground examinations have shown that seismic line and road construction may cause diversion of drainage and run-off. Deep cuts with complete removal of surface vegetation and surface organic soil material have caused ground subsidence followed by ponding of water and the formation of fens in otherwise mineral soil terrain.

8. Much of the area characterized by lacustrine and clay till deposits has a low trafficability and high erosion potential.

9. Organic terrain in this region is very susceptible to thaw and subsidence following disturbances.

10. Pipeline construction in the Wrigley area should not be allowed along the Mackenzie River Valley but should be located east of the Franklin Mountains where the terrain is more suitable for construction and also where environmental damage could probably be minimized.

9. IMPLICATIONS AND RECOMMENDATIONS

9.1 General Scientific Importance

As indicated previously in this report, the Wrigley area in the Mackenzie Valley is a transition area with respect to environmental factors, including the proximity to Cordilleran regions. Also this region of the N.W.T. has had little concentrated study in the past. Recognising that many of the following points have recently come under discussion and some are now being studied the authors recommend that:-

1. More long-term monitoring of both natural and man-affected terrain units be conducted so as to obtain more precise information about environmental processes.

2. Careful examination is required of drainage patterns and of the amounts and types of organic terrain as these relate to water, management, land-use hydrology and wildlife habitat.

3. More study is needed of the influences of climate, geologic material, soils and vegetation relationships on stream flow and soil processes following disturbance.

4. River and stream crossings being critical in this region characterized by fine-textured soils susceptible to erosion and slumping, the importance of the small streams, often intermittent but with rapid fluctuations in flow, should not be underestimated.

5. The mosaic of habitats which results from the complex fire history of the area should be examined for interrelationships regarding wildlife habitat, vegetation, soils and productivity.

6. As there is a general lack of aggregate for construction purposes within the Mackenzie Valley proper in the Wrigley area, attempts to obtain suitable aggregate from river and stream beds should be done with extreme caution. In some cases siltation may not be serious as the river waters contain sufficient cations to cause flocculation of finely-divided particles, however site-specific studies should be conducted prior to attempting to remove aggregate from these sources.

7. If sedimentary rocks are mined for aggregate, problems may result due to their high susceptibility to weathering down to silt and clay sized particles. The nature of the geologic material in the area illustrates the rapid chemical and physical weathering that has occurred in the sedimentary materials.

8. Consideration should be given to the feasibility of using indigenous or introduced plant species for revegetation of disturbed sites to minimize ground thawing and erosion problems.

9.2 Pipeline Construction and Operation

In addition, again recognising that events may have overtaken them, the authors direct special attention to the need for:-

1. Assessment of soil stability at all river crossings including intermittent streams.

2. Assessment of sources of construction aggregate for the

potential environmental impact of removal prior to granting of excavation permits. This is especially important if the use of river and stream bed material is contemplated.

3. Paying careful attention to surface drainage features. Much of the sloping area is naturally unstable and accelerated erosion and water diversion, are likely if great care is not exercised. Steeply sloping land should be avoided.

4. Avoiding organic soils or others with high ice content materials because of their susceptibility to damage. Where they must be utilized specific studies should be conducted prior to development.

5. Consideration being given to saving or stockpiling topsoil of humic gleysols, eutric and dystric brunisols, regosols and some gray luvisols for reclamation of disturbed areas.

6. Storage of materials, supplies, fuel and camps should not be allowed on floodplains nor near shore lines of lakes as a rapid rise of water level, as happened in July 1973, may result in flooding and pollution of waters. Similarily, camps and supply depots should be checked regularly and removed immediately following completion of projects.

7. Using areas where surficial geologic materials are shallow to bedrock, probably the most stable segments of the landscape, for construction as far as possible. Fissile shales and fault areas should be avoided.

8. Locating access roads to pipelines and other transportation corridors with care and taking account of soil materials, surface and subsurface drainage.

9.3 Researcher's Views

Impressions derived from the project conducted at Wrigley and Fort Simpson indicate that a transport corridor is feasible in the area if an understanding of the physical environment can be developed.

Intermittent burning has resulted in a variety of vegetative patterns reflecting different drainage, soil and ground frost conditions as well as the fire history.

Soil erosion and stability are problematic in certain regions which have been mapped in the study area.

The kinds, varieties and structures of organic terrain are imperfectly understood. These areas should receive greater attention. The lack of climatological data in the area makes the prediction of environmental effects difficult, especially hydrologic and ecological changes.

It is recommended that pipelines be located east of the Franklin Mountains in the Wrigley area. This is based on the general impression that the landscape there is more stable, that sources of aggregate are more abundant and that construction activities, maintenance and pipeline breakages would cause less

environmental harm if located away from the Mackenzie River. It is also recommended that winter operations be utilized as much as possible on silty and clayey soils of low natural trafficability.

10. NEEDS FOR FURTHER STUDY

Although there are numerous studies currently underway in the Mackenzie Valley pipeline corridor, not all are oriented towards an understanding of the basic physical environmental parameters in an integrative or interdisciplinary manner. These kinds of studies are becoming increasingly important in all areas of development. In this light, the following general types of study are recommended.

1. Long-term, site-specific studies that relate to environmental processes not only seasonally but also cyclically. This could include such things as more climatological instrumentation, ground frost dynamics, vegetation succession, erosion and slumping, stream discharge, organic terrain features, wildlife habitat, land use hydrology simulation and water quality.

2. The effects of gas and oil leakages or spills should be studied on major or important terrain types. This is especially important in areas of organic soils and open water.

3. It is desirable that studies be conducted towards elucidation of the factors involved in the distribution, thickness, depth and dynamics of ice in the various kinds of mineral and organic terrain so as to facilitate the prediction of the effects of disturbance.

4. More information is required regarding the utility of various types of remote sensing in the identification of problem or sensitive areas as well as to ensure the collection of sequential

data for long periods of time. To facilitate this, imagery must be taken at appropriate times of the year to allow the best use to be made of the potential of remote sensors for identifying and interpreting vegetation patterns and other site factors.

5. Due to the extent and environmental importance of organic terrain in Canada's north, it is suggested that more detailed studies of organic terrain be undertaken. These studies should be multi-disciplinary to develop a uniform taxonomy that can be used for various kinds of classifications.

6. The effects of natural processes of erosion, slumping and mass-wasting should be studied in order to evaluate man-induced changes as they affect the biology and other physical environmental factors.

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12. APPENDICES

12.1 List of Vegetation; Common and Scientific Names

Common Names	Scientific Names
TREES	
(white) Birch	*Betula papyrifera*
Tamarack	*Larix laricina*
White spruce	*Picea glauca*
Black spruce	*Picea mariana*
Jack pine	*Pinus banksiana* (*divaricata*)
Lodgepole pine	*Pinus contorta*
Balsam poplar	*Populus balsamifera*
Aspen	*Populus tremuloides*
SHRUBS	
Alder	*Alnus crispa*
Saskatoon berry, serviceberry	*Amelanchier alnifolia*
Moorwart	*Andromeda polifolia*
Arctic bearberry	*Arctostaphylos arctica*
Kinnikinnik	*Arctostaphylos rubra*
Bearberry	*Arctostaphylos uva-ursi*
Bog birch, Dwarf birch	*Betula glandulosa*
Moss heather	*Cassiope tetragona*
Leatherleaf	*Chamaedaphne calyculata*
Red Osier Dogwood	*Cornus stolonifera*
Crowberry	*Empetrum nigrum*
Juniper	*Juniperus communis*
Crawling juniper	*Juniperus horizontalis*
Bog laurel	*Kalmia polifolia*

Arctic labrador tea	*Ledum decumbens*
Labrador tea	*Ledum groenlandicum*
Sweet gale	*Myrica gale*
Small bog cranberry	*Oxycoccus microcarpus*
Shrubby cinquefoil	*Potentilla fruticosa*
Purple rhododendron	*Rhododendron lapponicum*
Gooseberry	*Ribes* spp.
Rose	*Rosa acicularis*
Baked appleberry	*Rubus chamaemorus*
Dwarf raspberry	*Rubus pubescens*
Willow	*Salix reticulata*
Scouler's willow	*Salix scouleriana*
Willow	*Salix* spp.
Soapberry, Buffalo berry	*Shepherdia canadensis*
Blueberry	*Vaccinium uliginosum*
Cowberry	*Vaccinium vitis-idaea*
Squashberry	*Viburnum edule*

HERBS

Monkshood	*Aconitum columbianum*
	Androsace chamaejasme
Anemone	*Anemone parviflora*
Arnica	*Arnica* spp.
Aster	*Aster* sp.
Comandra	*Commandra livida*
Bunchberry	*Cornus canadensis*
Moccasin flower	*Cypripedium passerinum*

Roundleaf sundew	Drosera rotundifolia
Yellow dryas	Dryas drummondii
Dryas	Dryas sp.
Fireweed	Epilobium angustifolium
Wild strawberry	Fragaria virginiana
Northern bedstraw	Galium boreale
Hedysarum	Hedysarum alpinum
Twinflower	Linnea borealis
Lupine	Lupinus sp.
Arctic lupine	Lupinus arcticus
Miterwort	Mitella nuda
Locoweed	Oxytropis maydelliana
Wood botany	Pedicularis bracteosa
Lousewort	Pedicularis kanei
Contorted lousewort	Pedicularis contorta
	Pinguicula sp.
Coltsfoot	Petasites palmatus
Green pyrola	Pyrola asarifolia
One sided pyrola	Pyrola secunda
Dock	Rumex sp.
Spotted saxifrage	Saxifraga bronchialis
Common groundsel	Senecio sp.
Moss campion	Silene acaulis
Threeleaf smila	Smilacina trifolia
Goldenrod	Solidago sp.
Boreal tofieldia	Tofieldia borealis
Tofieldia	Tofieldia sp.

Violet	*Viola renifolia*
White camas	*Zygadenus elegans*
GRAMINOIDS	
Redtop	*Agrostis alba*
Brome	*Bromus vulgaris*
Blue joint	*Calamagrostis canadensis*
Sedge	*Carex* spp.
Cotton grass	*Eriophorum* sp.
Horsetail	*Equisetum arvense*
	Equisetum pratense
	Equisetum scirpoides
	Equisetum sylvaticum
SPHAGNA	
Sphagnum	*Sphagnum* spp.
MOSSES	
	Abietina sp.
Ribbed bog moss	*Aulacomnium palustre*
	Brachythecium sp.
	Campylium arcticum
	Catascopium stellatum
	Cinclidium arcticum
	Dicranum spp.
Wavy dicranum	*Dicranum undulatum*
	Drepanocladus revolvens
	Drepanocladus exannulatus

Feather moss	*Hylocomium splendens*
Ground cedar	*Lycopodium complanatum*
	Meesia triquetra
	Meesia uliginosa
Schrebers moss	*Pleurozium schreberi*
Hair cap moss	*Polytrichum* spp.
	Ptilium crista-castrensis
Liverwort	*Ptilium ciliare*
	Rhytidium rugosum
	Scorpidium scorpioides
	Tortella tortuosa
	Tomenthypnum nitens

LICHENS

	Alectoria octocruka
Reindeer mosses	*Cladina alpestris*
	Cladina amaurocraea
	Cladina arbuscula
	Cladina cariosa
	Cladina chlorophaea
	Cladina cornuta
	Cladina deformis
	Cladina rangiferina
	Cladina scabriuscula
	Cetraria cuculata
	Cetraria islandica

	Cetraria tilesii
	Cetraria richardsonii
	Lecanora epibryon
	Stereocaulon tomentosum
Peltigera	_Peltigera aphthosa_

12.2 Soil and Vegetation Description

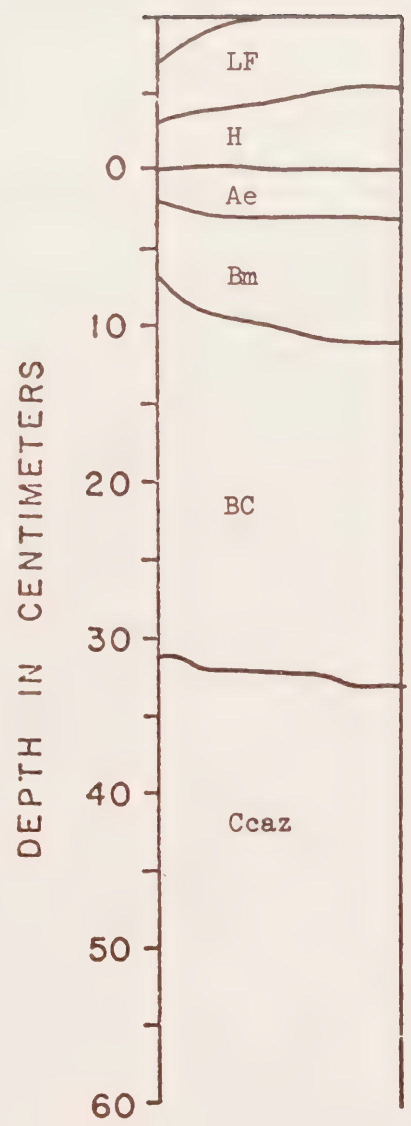
A; Alluvium

A1; Alluvial terrace or plain

(a) Degraded Dystric Brunisol

These soils are found on variable textured (dominantly silt loam) alluvial terraces adjacent to the Mackenzie River and are moderately well drained. The vegetation is a mixture of white spruce, birch, rose and various herbs, shrubs and feathermosses (Figure 55).

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m				x		Picea glauca, Picea mariana
<10 m						
Shrubs						
>2 m						
1-2 m		x				Alnus crispa, salix spp.
<1 m				x		Ledum groenlandicum, Rosa acicularis
Herbs			x			Vaccinium vitis - idaea, Comandra livida
Graminoids						
Sphagna						
Mosses					x	Hylocomium splendens
Lichens	x					Cladonia mitis, Peltigera aphthosa



A1; Degraded Dystric Brunisol

LF - decomposing organic litter

H - partially decomposed organic material.

Ae - light gray (10YR 7/2); silt loam; single grained; structureless; loose; pH 4.1; gradual and wavy boundary

Bm - pale yellow (2.5Y 7/4); clay; moderate fine subangular blocky; very sticky; pH 4.7; wavy boundary; temperature at 20 cm, 2.0°C

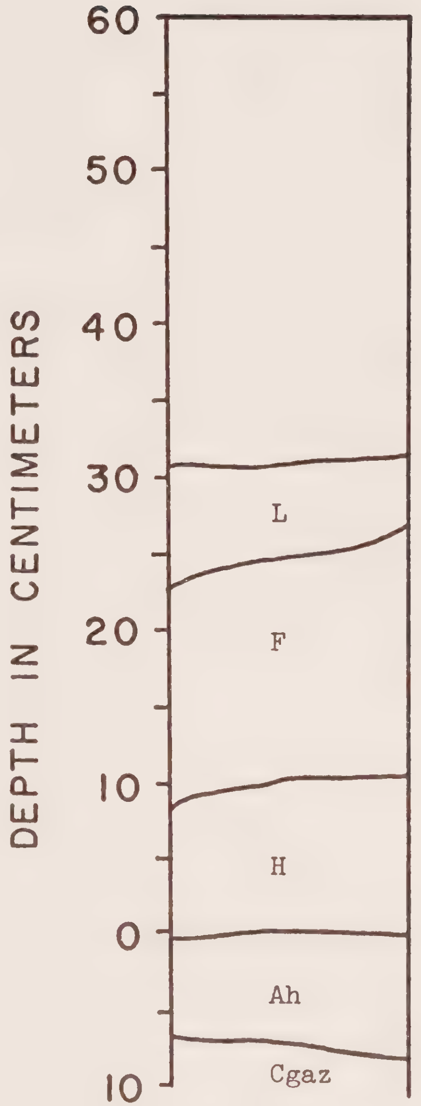
BC - light yellowish brown (2.5Y 6/4); loam; granular; friable; pH 5.9

Ccaz - light yellowish gray (2.5Y 6/2); silt loam; massive; pH 7.3; temperature at 50 cm, 2.0°C

(b) Peaty Rego Humic Gleysol

These soils are found in imperfectly to poorly drained depressional areas and receiving positions on the slope. The vegetation is dominantly black spruce, labrador tea, feathermosses and reindeer mosses.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees > 20 m						
10-20 m						
<10 m		x				Picea mariana, scattered Larix laricina, Populus tremuloides
Shrubs > 2 m						
1-2 m						
< 1 m		x				Ledum groenlandicum, Salix spp., Arctostophylos rubra, Vaccinium vitis-idaea, Potentilla fruiticosa
Herbs						
Graminoids	x					Equisetum spp., Carex spp.
Sphagna						
Mosses			x			Hylocomium splendens, Dicranum sp.
Lichens		x				Cladonia rangiferina



A1; Peaty Rego Humic Glysol

L - moss remains

F - partly decomposed organic matter

H - decomposed organic matter

Ah - very dark grayish brown (10YR 3/2); loam; single grained, structureless; loose; non-sticky; pH 6.2

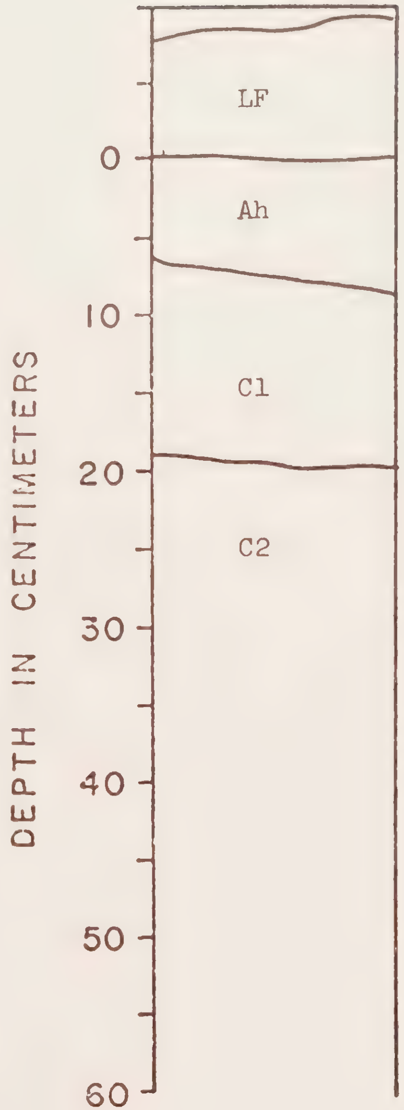
Cgaz - dark grayish brown (10YR 4/2); loam; pH 6.4

A2; Creek floodplain

(a) Cumulic Regosol

These soils are moderately well- to imperfectly-drained and develop on alluvial deposits adjacent to small, well defined creeks and rivers (Figure 56). They are associated with poorly-drained Peaty Gleysol and Organic soils. The vegetation is a mixture of white spruce, bog birch, labrador tea and feathermosses.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m			x			Picea mari~~n~~ana, Larix laricina, Picea glauca
Shrubs >2 m						
1-2 m						
<1 m			x			Betula glandulosa, Alnus crispa, Ledum groenlandicum, Salix spp., Potentilla fruticosa, Vaccinium vitis-idaea, Shepherdia canadensis
Herbs						
Graminoids				x		Cornus canadensis, Eriophorum
Sphagna						
Mosses		x				Dicranum undulatum, Lycopodium annotinum, Campthothicium nitens Hylocomium splendens
Lichens	x					Cladonia mitis



A2; Cumulic Regosol

LF - decomposing organic material.

Ah - very dark brown (10YR 2/2); silty clay loam; single grained, structureless; pH 6.2

C1 - very dark grayish brown (10YR 3/2); loam; single grained, structureless; loose, non-sticky; pH 6.2

C2 - very dark brown (10YR 2/2); silt loam; loose, non-sticky; pH 6.4; temperature at 20 cm, 2.0°C; temperature at 50 cm; 0°C

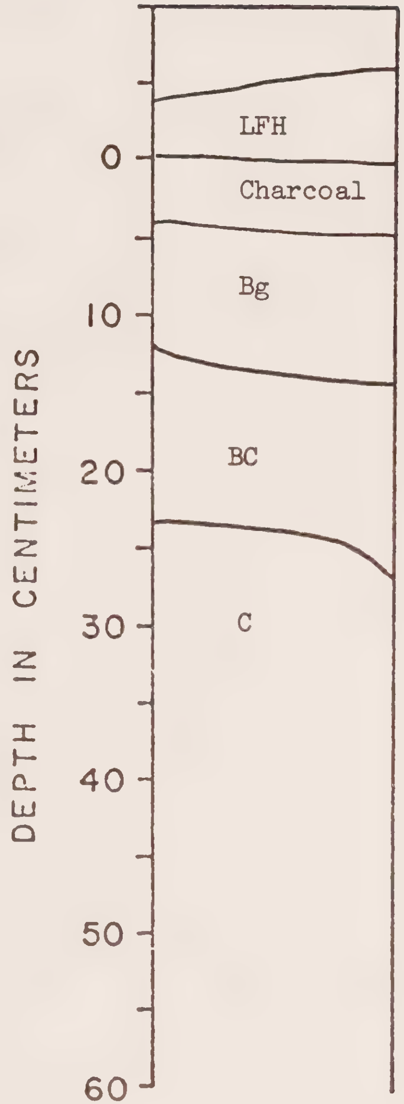
C; Colluvium

Cl; Colluvial fan

(a) Orthic Gleysol

These soils are gravelly loamy sand to gravelly sandy loam textured and occur in areas of coalescing colluvial fans consisting of a mixture of colluvium, alluvium and till. The soils are generally imperfectly- to poorly-drained. The vegetation consists mainly of white spruce, bog birch, willow, sedges and reindeer mosses.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m	x					*Picea glauca* (krummholz)
Shrubs >2 m						
1-2 m						
<1 m		x				*Betula glandulosa*, *Salix* spp.,
Herbs						
Graminoids		x				*Carex* spp.
Sphagna						
Mosses						
Lichens		x				*Caldonia rangiferina*



Cl; Orthic Glysol

LFH - decomposing organic material.

Bg - brown (10YR 5/3m); sandy loam; weak, medium; subangular blocky; firm; non-sticky; gradual, wavy boundary; pH 6.6

BC - reddish brown (5YR 4/3); loamy sand; granular, friable; pH 6.6

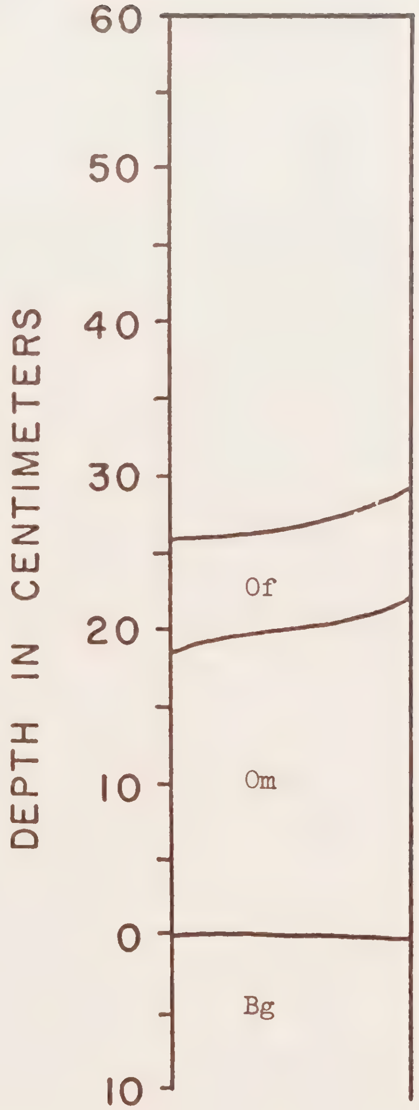
C - dark reddish gray; loamy sand; loose; non-sticky; pH 6.4

(b) Peaty Orthic Gleysol

These soils are poorly-drained and are located mainly in depressions on the landscape (Figure 57). The entire colluvial fan area is composed of complex slopes. Vegetation is dominantly sedges, willow, and krummholz white spruce.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m						
<10 m	x					*Picea glauca* (krummholz)
Shrubs						
>2 m						
1-2 m						
<1 m		x				*Salix* spp.
Herbs						
Graminoids		x				*Carex* spp., *Eriophorum spissum*, *Equisetum* sp.
Sphagna						
Mosses						
Lichens						

Cl; Peaty Orthic Glysol



Of - undecomposed fibric organic matter.

Om - intermediately decomposed organic matter.

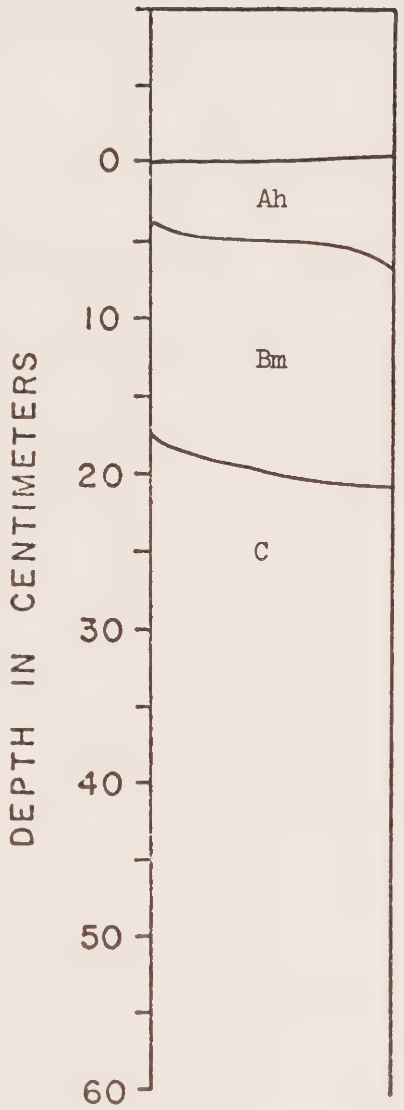
Bg and Cg similar to Cl; Orthic Gleysol

C2; Colluvial plain

(a) Alpine Eutric Brunisol

The landscape where this soil is developed consists mainly of a steep colluvial plain dissected by water channels. The texture is gravelly sandy loam to gravelly loam and the soil is well- to moderately-well drained.

Vegetation Strata and Cover	1–5%	5–25%	25–50%	50–75%	75–100%	Species Composition and Remarks
Trees >20 m						
10–20 m						
<10 m		x				*Picea glauca* (krummholz)
Shrubs >2 m						
1–2 m						
<1 m		x				*Potentilla fruticosa*, *Pedicularis labradorica*
Herbs	x					*Dryas integrifolia*
Graminoids						
Sphagna						
Mosses						
Lichens		x				*Cladonia rangiferina*



C2; Alpine Eutric Brunisol

Ah - dark yellowish brown; gravelly loam; granular; pH 7.0

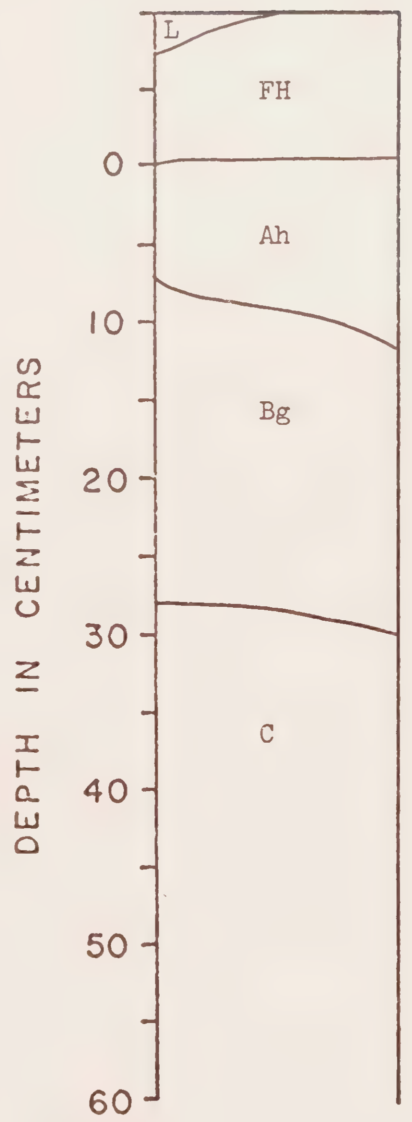
Bm - pale brown; sandy loam; moderate, medium, subangular blocky; pH 7.1; gradual, wavy boundary

C - olive brown; sandy loam; pH 7.2

(b) Peaty Orthic Humic Gleysol

These soils are imperfectly- to poorly-drained. Normally, they are found in an alpine-like meadow environment. There is much mixing of organic and mineral material throughout the solum.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m						
<10 m		x				_Picea glauca_
Shrubs						
>2 m						
1-2 m						
<1 m		x				_Salix_ spp., _Vaccinium vitis-idaea_, _Empetrum nigrum_
Herbs						
Graminoids		x				_Carex_ spp., _Eriophorum spissum_
Sphagna						
Mosses						
Lichens	x					_Cladonia rangiferina_



C2; Peaty Orthic Humic Glysol

L - organic litter material

FH - decomposing organic material

Ah - very dark brown; turfy; sandy clay loam; granular; pH 6.2

Bg - grayish brown; clay loam; massive; friable, sticky; pH 6.8 wavy boundary.

C - grayish brown; sandy loam; friable, non-sticky; pH 7.2

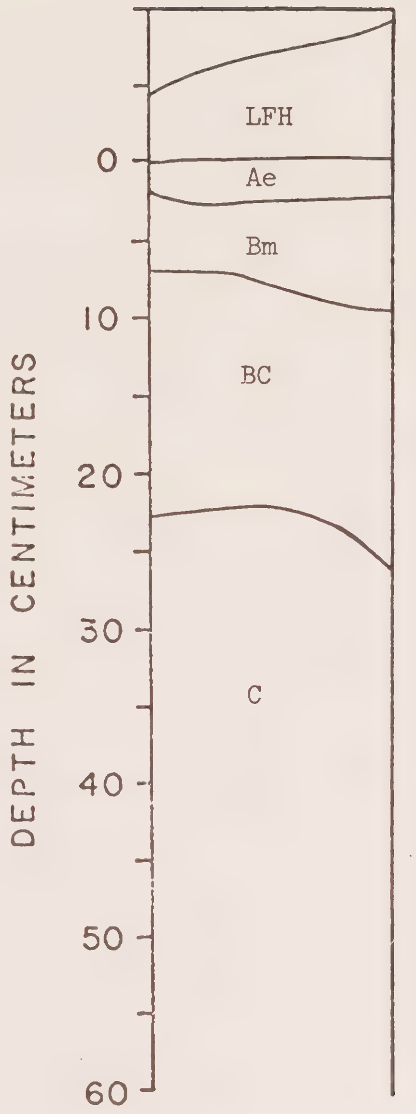
T; Glacial Till

Tl; Till plain

(a) Degraded Dystric Brunisol

These soils are developed from silt loam to clay loam textured material and are moderately well-drained (Figure 58). The topography is slightly undulating. Vegetation is mainly black spruce, labrador tea, various shrubs, herbs, feathermoss and reindeer mosses.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m			x			Picea mariana
Shrubs >2 m						
1-2 m						
<1 m			x			Ledum groenlandicum; Vaccinium vitis-idaea, Salix spp., Rosa sp., Betula glandulosa
Herbs				x		Vaccinium vitis-idaea, Comandra livida, Cornus canadensis, Empetrum nigrum
Graminoids						
Sphagna						
Mosses				x		Hylocomium splendens, Ptilium crista-castrensis
Lichens			x			Cladonia mitis, Cladonia alpestris, Cladonia rangiferina, Citraria cuculata, Peltigera aphthosa



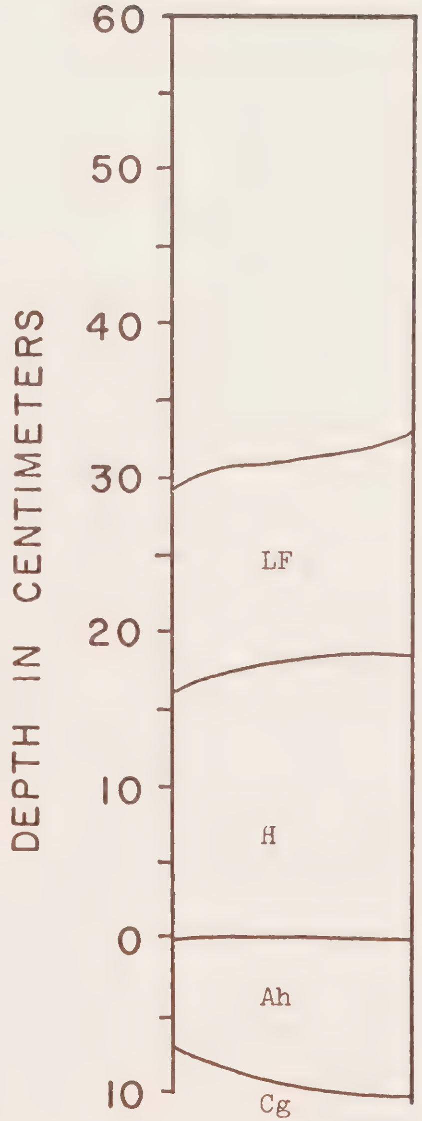
T1; Degraded Dystric Brunisol

LFH	-	decomposing organic material
Ae	-	light gray; weak platy; slightly sticky
Bm	-	light yellowish brown; silt loam; weak subangular blocky; slightly sticky; pH 4.0; wavy boundary
BC	-	very pale brown; loam; subangular blocky; pH 4.2; temperature at 20 cm, 1.0°C
C	-	light brownish gray; loam to silt loam; pH 4.7; temperature at 50 cm, 0.5°C

(b) Peaty Rego Humic Gleysol

In the drainage channels and receiving areas this is the dominant soil. The soil is poorly-drained. Vegetation consists mainly of black spruce, willow, bog birch, sphagnum and reindeer mosses.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m		x				Picea mariana, Larix laricina
<10 m						
Shrubs >2 m						
1-2 m			x			Betula glandulosa, Salix spp., Ledum groenlandicum
<1 m						
Herbs						
Graminoids						
Sphagna		x				Sphagnum spp.
Mosses						
Lichens	x					Caldonia rangiferina, Cladonia alpestris



T1; Peaty Rego Humic Glysol

LF - decomposing organic litter

H - partially decomposed organic material

Ah - very dark brown; sandy loam; granular pH 6.2

Cg - brown; sandy loam; friable, non-sticky; pH 7.1; temperature at 20 cm, 2°C; temperature at 50 cm, 1°C

Tl.1; Till plain

(a) Peaty Rego Humic Gleysol

This soil is similar to that described for Tl - Peaty Rego Humic Gleysol.

(b) Cryic Fibrisol

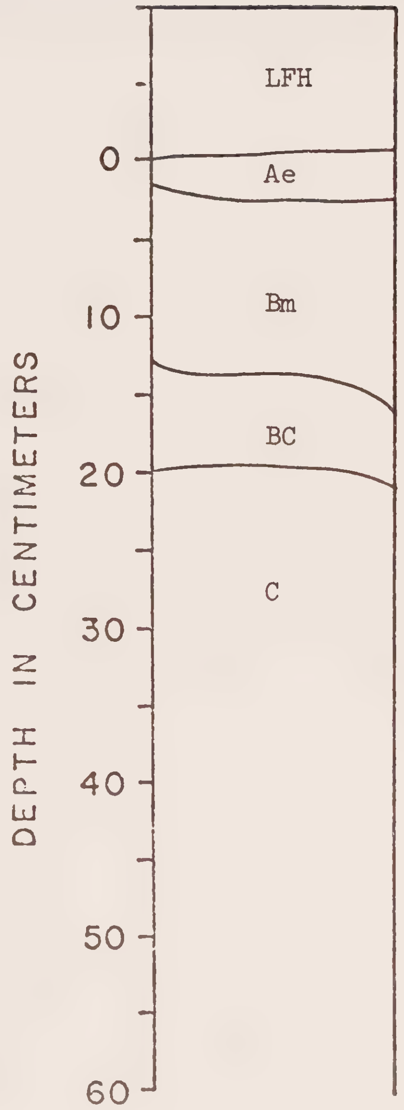
This poorly-drained soil is located mainly in depressions on the landscape. It is normally associated with a peat plateau area developed from sphagnum mosses. The depth to ice is usually 35 cm. Vegetation consists mainly of scattered black spruce, bog birch, labrador tea, sphagnum mosses and reindeer mosses.

T2; Drumlinized till plain

(a) Degraded Dystric Brunisol

These soils are moderately well-drained and are found on a wide variety of complex slopes. The texture is a gravelly sandy loam to gravelly loam.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m			x			Picea mariana, Betula papyrifera
<10 m						
Shrubs						
>2 m						
1-2 m			x			Betula glandulosa, Ledum groenlandicum, Arctostophylos rubra Vaccinium vitis-idaea
<1 m						
Herbs		x				Cornus canadensis
Graminoids						
Sphagna						
Mosses			x			Hylocomium splendens
Lichens		x				Cladonia alpestris, Cladonia rangiferina, Cladonia mitis



T2; Degraded Dystric Brunisol

LFH - decomposing organic material

Ae - pinkish gray; weak, platy; slightly sticky; pH 3.7

Bm - yellowish red; sandy clay loam; structureless; slightly sticky; pH 4.5; gradual, wavy boundary

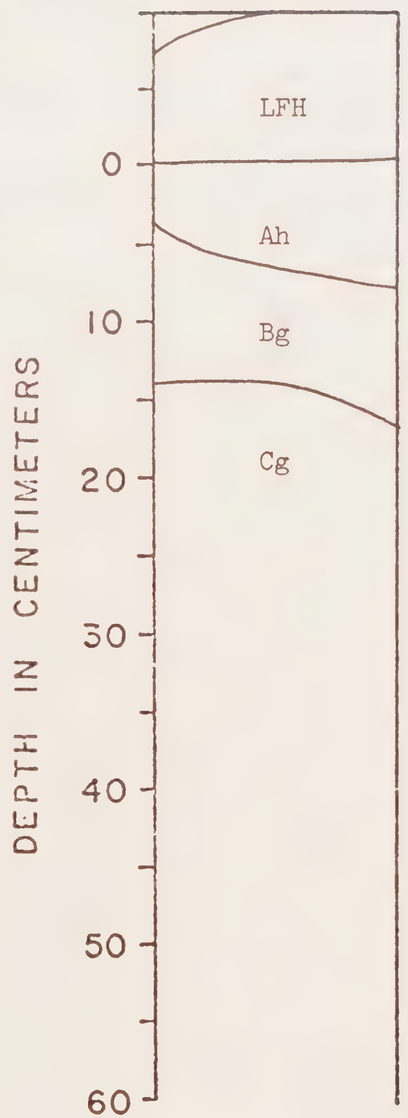
BC - strong brown; sandy loam; structureless, single grained; friable, slightly sticky; pH 5.3; temperature at 20 cm, 7°C

C - brown; loam; non-sticky; pH 7.2; temperature at 50 cm, 5°C

(b) Orthic Humic Gleysol

These are poorly drained soils found on shallow slopes in seepage (receiving) positions and depressions (Figure 59).

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m		x				Pinus banksiana, Picea mariana, Betula papyrifera
<10 m					x	Picea mariana
Shrubs						
>2 m	x					Alnus crispa
1-2 m	x					Alnus crispa, Salix spp., Betula glandulosa
<1 m	x					Ledum groenlandicum, Rosa acicularis, Vaccinium uliginosum, Arctostaphylos rubra, Salix spp.
Herbs	x					Mitella nuda, Pyrola asarifolia, Comandra livida, Petasites palmatus
Graminoids	x					Equisitum scirpoides, Carex spp.
Sphagna						
Mosses					x	Hylocomium splendens, Ptilidium ciliare
Lichens	x					Cladonia mitis, Peltigera aphthosa



T2; Orthic Humic Glysol

LFH - decomposing organic material

Ah - very dark brown; sandy loam; granular; pH 5.8

Bg - dark yellowish brown; sandy loam; massive; friable, slightly sticky; pH 6.2; distinct boundary.

Cg - very dark grayish brown; loam; friable, non-sticky; pH 6.8; temperature at 20 cm, $4^{o}C$; temperature at 50 cm, $2^{o}C$.

(c) Cryic Fibrisol

These soils are similar to Tl.1 - Cryic Fibrisol.

T2.1; Drumlinized till plain

(c) Peaty Orthic Humic Gleysol

This soil and associated vegetation are similar to T2 - Peaty Orthic Humic Gleysol.

(b) Cryic Fibrisol

These poorly-drained soils and associated vegetation are similar to T2 - Cryic Fibrisol.

(c) Degraded Dystric Brunisol

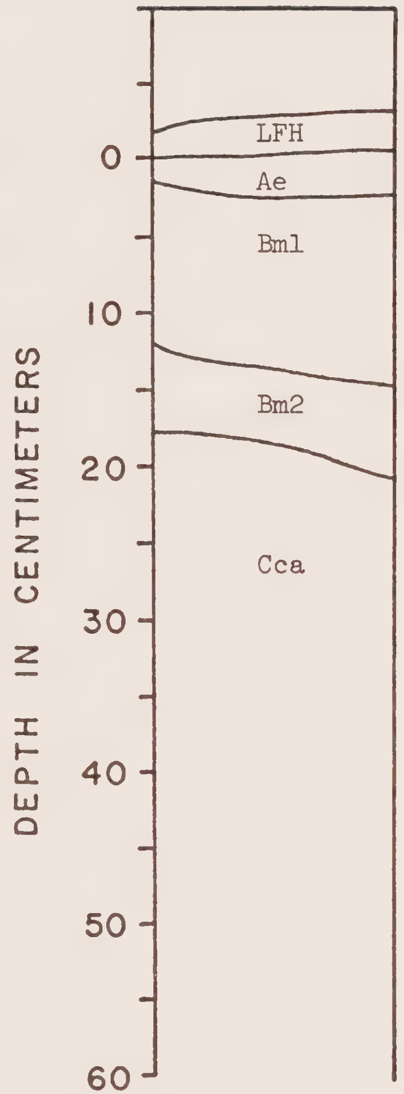
These soils and associated vegetation are similar to T2 - Degraded Dystric Brunisol.

T3; Eroded till plain

(a) Degraded Eutric Brunisol

These moderately well-drained soils are associated with the extremely hummocky area in the eastern portion of the study area. The texture is a gravelly sandy loam. Vegetation consists mainly of black spruce, lodgepole pine, birch, various shrubs, herbs, feathermoss and reindeer mosses.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m		x				Pinus contorta, Betula papyrifera, Picea mariana
<10 m			x			Picea mariana
Shrubs >2 m						
1-2 m		x				Alnus crispa
<1 m		x				Vaccinium vitis-idaea
Herbs						
Graminoids						
Sphagna						
Mosses	x					Hylocomium splendens
Lichens	x					Cladonia alpestris



T3; Degraded Eutric Brunisol

LFH	-	decomposing organic material
Ae	-	light brownish gray; sandy loam; weak, platy; pH 3.6
Bm1	-	strong brown; sandy loam; fine subangular blocky; pH 4.7; clear, wavy boundary
Bm2	-	dark yellowish brown; clay loam; medium blocky; pH 6.6; gradual, wavy boundary; temperature at 20 cm, $5^{o}C$
Cca	-	brown; sandy loam; friable, non-sticky; pH 7.0; temperature at 50 cm, $4^{o}C$

(b) Cryic Fibrisol

This is the dominant soil developed in the peat plateau areas which are located within the matrix of hummocky till remnants. The soil is poorly-drained with ice at approximately 30 cm.

T4; Till shallow to bedrock

(a) Degraded Dystric Brunisol

This soil is developed from silt loam to clay loam textured material. The soil is moderately well-drained. Vegetation consists mainly of black spruce, lodgepole pine, birch, feathermoss and reindeer mosses. The texture is variable due to the different rock types. The soil is similar to that described for T1 - Degraded Dystric Brunisol.

(b) Peaty Rego Humic Gleysol

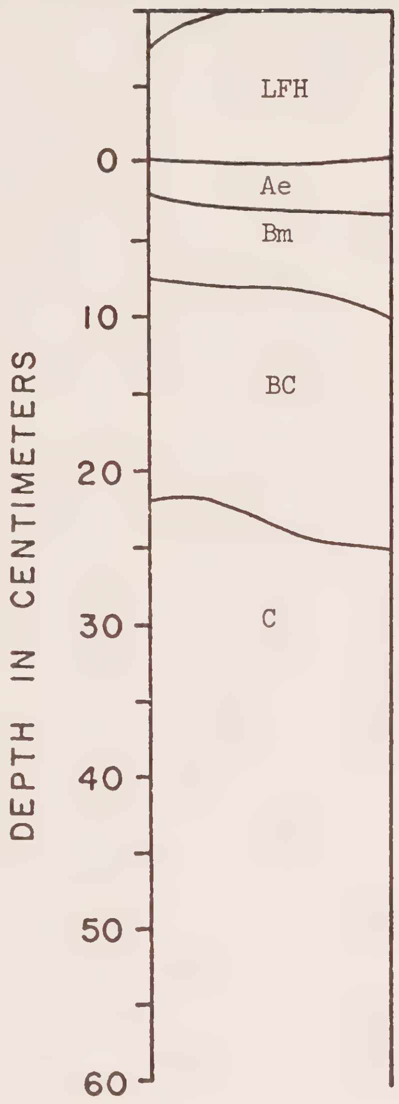
These soils and associated vegetation are similar to Tl - Peaty Rego Humic Gleysol.

T5; Till Complex

(a) Degraded Dystric Brunisol

These soils are derived from a mixture of glacial till, colluvium and alluvium in differing properties. The material is mainly of a gravelly loam texture and the soil is moderately well- to imperfectly drained. Vegetation consists mainly of black spruce, labrador tea, various herbs, feathermoss and reindeer mosses.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m						
<10 m			x			Picea mariana
Shrubs						
>2 m						
1-2 m						
<1 m			x			Ledum groenlandicum, Rosa acicularis, Vaccinium vitis-idaea
Herbs			x			Comandra livida
Graminoids	x					Equisetum arvense
Sphagna						
Mosses				x		Hylocomium splendens, Ptilium crista-castrensis
Lichens				x		Cladonia mitis, Cladonia rangiferina, Cladonia alpestris, Cetraria cuculata



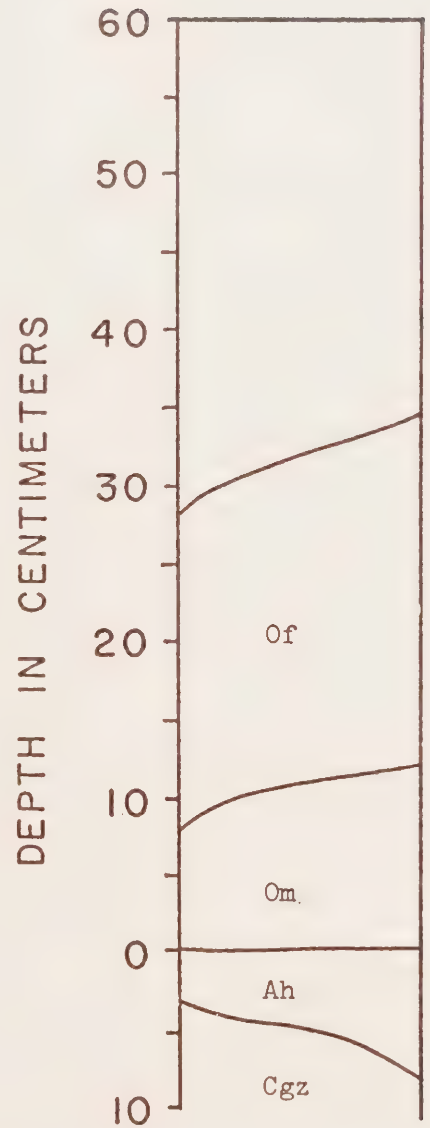
T5; Degraded Dystric Brunisol

LFH	-	decomposing organic material
Ae	-	light brownish gray; silty clay loam; weak, platy
Bm	-	very pale brown; silt loam; weak subangular blocky; slightly sticky; pH 3.9; gradual irregular boundary
BC	-	pale olive; silty clay loam; weak subangular blocky; pH 4.2; temperature at 20 cm, 2.0°C
C	-	light brownish gray; loam; single grained; pH 4.2; temperature at 50 cm, 1.0°C

(b) Peaty Rego Humic Gleysol

This poorly-drained soil is developed mainly in receiving areas. There is evidence of much frost churning in these soils with some ice lensing. Dominant vegetation consists of black spruce, bog birch, shrubs, herbs and reindeer mosses.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m						
<10 m			x			Picea mariana
Shrubs						
>2 m						
1-2 m						
<1 m					x	Betula glandulosa, Salix spp., Ledum groenlandicum, Ledum decumbens, Rosa sp., Andromeda polifolia, Vaccinium vitis-idaea, Arctostaphylos rubra
Herbs		x				Petasites sp.
Graminoids		x				Equisetum scirpoides
Sphagna		x				Sphagnum fuscum, Sphagnum spp.
Mosses		x				Dicranum undulatum, Pleurozium schreberi, Aulacomnium palustre
Lichens			x			Cladonia mitis, Cladonia alpestris, Cladonia rangiferina



T5; Peaty Regó Húmic Gleysol

Of	-	undecomposed fibric organic matter
Om	-	intermediately decomposed organic material
Ah	-	dark brown; sandy loam; single grained; pH 5.3
Cgz	-	brown; sandy loam; weak subangular blocky; friable, non-sticky

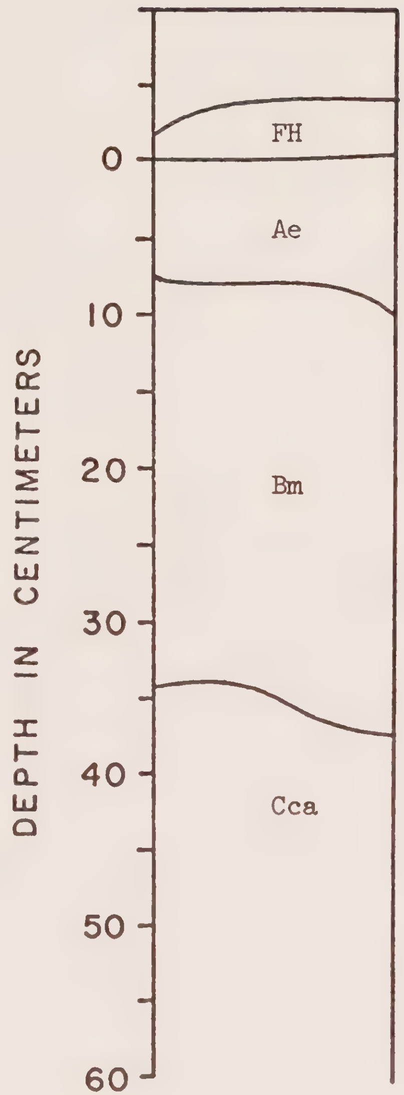
G; Glacial Outwash

G1; Kames and esker segments

(a) Degraded Dystric Brunisol

These soils are formed on gravelly loam to gravelly sandy loam textured outwash material located near the eastern portion of the study area and are well-drained. The material consists of well sorted sands and gravels, calcareous at depth.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m			x			Pinus banksiana, Picea mariana
Shrubs >2 m						
1-2 m						
<1 m		x				Ledum groenlandicum, Vaccinium vitis-idaea, Rosa acicularis, Empetrum nigrum
Herbs		x				Cornus canadensis, Epilobium angustifolium, Comandra livida
Graminoids						
Sphagna						
Mosses	x					Ptilidium ciliare, Dicranum undulatum, Lycopodium complanatum, Pleurozium schreberi
Lichens			x			Cladonia mitis, Cladonia alpestris, Cladonia rangiferina, Peltigera aphthosa



G1; Degraded Dystric Brunisol

FH - decomposing organic material

Ae - light gray; silt loam; weak, platy; pH 3.5

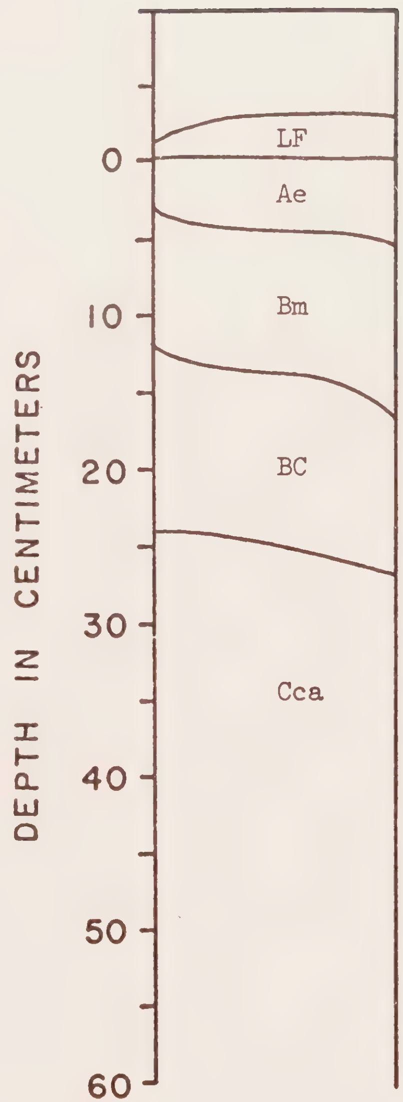
Bm - yellowish red; gravelly loamy sand; single grained, structureless; friable, non-sticky; pH 4.2; temperature at 20 cm, 8°C

Cca - brown; gravelly coarse sand; single grained, structureless; friable, non-sticky; pH 6.4; temperature at 50 cm, 5°C

(b) Degraded Eutric Brunisol

These soils are developed on slightly stratified kame deposits and are well-drained. Vegetation consists mainly of white spruce, aspen, alder, various shrubs, herbs and feathermoss.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m				x		Picea glauca
10-20 m						
<10 m		x				Betula papyrifera, Populus tremuloides
Shrubs						
>2 m						
1-2 m	x					Alnus crispa, Viburnum edule, Rosa sp., Juniperus communis
<1 m				X		Shepherdia canadensis, Vaccinium vitis-idaea
Herbs		x				Galium boreale, Pyrola asarifolia, Cornus canadensis, Arnica sp., Hedysarum alpinum
Graminoids						
Sphagna						
Mosses	x					Hylocomium splendens
Lichens						



G1; Degraded Eutric Brunisol

LF - organic litter material

Ae - light gray; loam; weak platy; pH 5.4

Bm - dark yellowish brown; clay; weak subangular blocky; sticky; pH 5.8

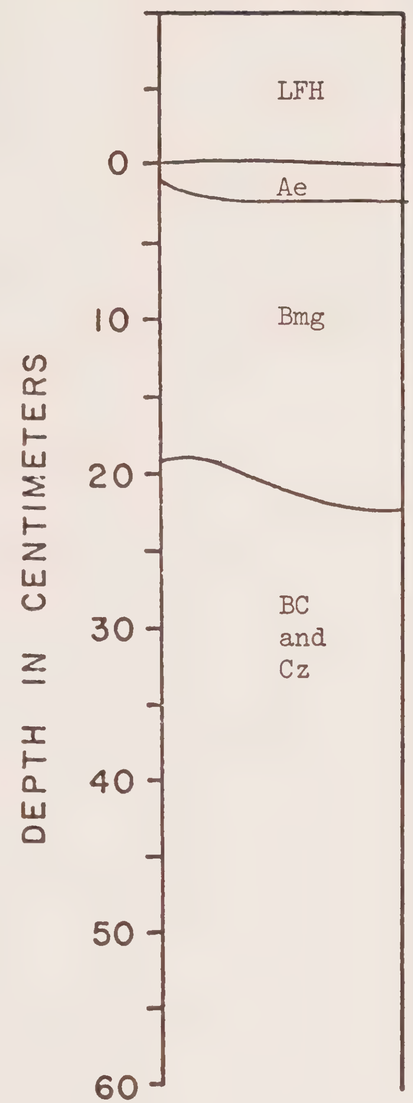
BC - brown; clay loam; slightly sticky; pH 7.2; temperature at 20 cm, 11°C

Cca - dark grayish brown; gravelly loam; non-sticky; pH 7.3; temperature at 50 cm, 10°C.

(d) Gleyed Degraded Dystric Brunisol

These soils are developed in the receiving position at the base of the ridge or hummock. The material consists of sorted sands and gravel with ice at 75 cm. The soil is imperfectly- to poorly-drained.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m			x			Picea mariana, Betula papyrifera
<10 m						
Shrubs						
>2 m	x					Alnus crispa
1-2 m	x					Alnus crispa, Betula glandulosa
<1 m			x			Ledum groenlandicum, Vaccinium vitis-idaea, Rosa acicularis, Empetrum nigrum
Herbs						
Graminoids						
Sphagna						
Mosses					x	Hylocomium splendens, Ptilium crista-castrensis, Pleurozium schreberi
Lichens	x					Cladonia alpestris, Cladonia rangiferina, Cladonia mitis



Gl; Gleyed Degraded Dystric Brunisol

LFH - decomposing organic matter

Ae - pinkish gray; sandy loam; weak, single grained; pH 3.2

Bmg - brown (5YR 4/4m); loam; single grained, structureless; friable, non-sticky; pH 3.9; gradual, wavy boundary; temperature at 20 cm, $2^{o}C$

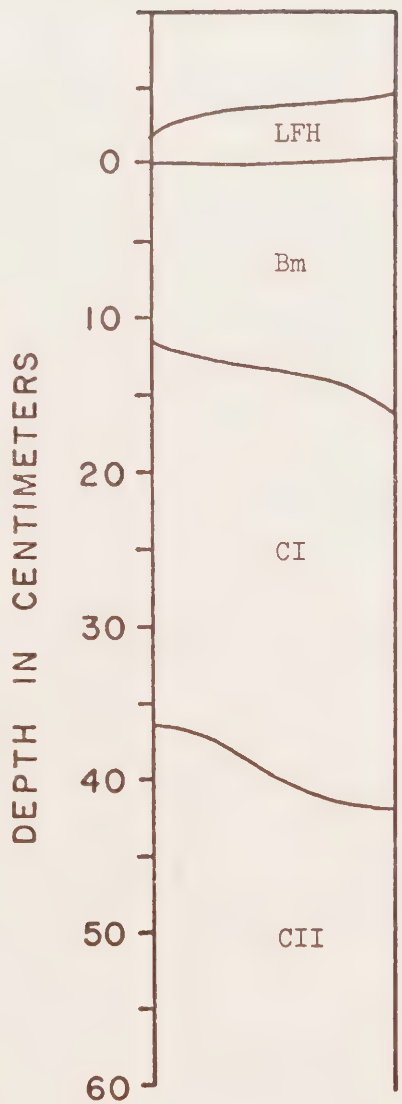
BC - dark brown; friable, non-sticky; pH 6.3; temperature at 50 cm, $0^{o}C$

G2; Esker and esker complex

(a) Orthic Eutric Brunisol

These soils are developed on roughly sorted sands and gravels. The texture is gravelly sandy loam and the soil is well- to rapidly-drained.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m	x					*Picea glauca*, *Betula papyrifera*, *Pinus banksiana*
Shrubs >2 m						
1-2 m		x				*Alnus crispa*, *Shepherdia canadensis*
<1 m			x			*Vaccinium vitis-idaea*, *Viburnum edule*, *Linnaea borealis*, *Arctostaphylos uva-ursi*, *Rosa acicularis*
Herbs	x					*Epilobium angustifolium*, *Galium boreale*, *Pyrola secunda*
Graminoids						
Sphagna						
Mosses		x				*Polytrichum* sp., *Pleurozium schreberi*
Lichens		x				*Peltigera aphthosa*, *Cladonia mitis*



G2; Orthic Eutric Brunisol

LFH - decomposing organic litter

Bm - yellowish brown; sandy loam; single grained, structureless; friable, slightly sticky; pH 5.9; abrupt, smooth boundary

CI - brown; single grained, structureless; friable, non-sticky; pH 7.2; temperature at 20 cm, 15°C

CII - pale brown; single grained, structureless; friable, non-sticky; pH 7.0; temperature at 50 cm, 12°C

G2.1 Esker and esker segments

(a) Gleyed Degraded Dystric Brunisol

In the receiving position at the base of the slope and in depressional areas, this imperfectly to poorly-drained soil is developed. The vegetation is similar to G1 - Gleyed Degraded Dystric Brunisol.

(b) Cryic Fibrisol

Within the matrix of outwash material, there are areas of open bogs and peat plateau. This poorly-drained soil is the dominant soil of this area. Vegetation consists largely of scattered black spruce and sphagnum.

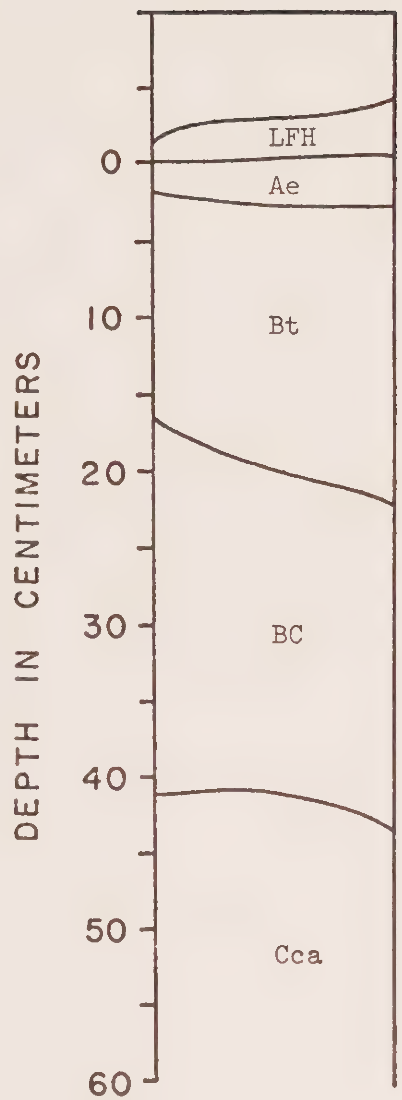
L; Lacustrine

L1; Lacustrine plain

(a) Orthic Gray Luvisol

The lacustrine deposits are found mainly adjacent to the alluvial deposits along the Mackenzie River. This soil is of a silty clay texture and is moderately well to imperfectly-drained (Figure 60).

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m					x	Populus tremuloides
<10 m		x				Picea glauca
Shrubs >2 m				x		Alnus crispa
1-2 m						
<1 m		x				Viburnum edule, Rosa sp., Shepherdia canadensis, Linnaea borealis, Vaccinium vitis-idaea
Herbs			x			Cornus canadensis, Pyrola secunda
Graminoids						
Sphagna						
Mosses	x					Hylocomium splendens, Dicranum rugosum
Lichens	x					Peltigera aphthosa



L1; Orthic Gray Luvisol

LFH - decomposing organic material

Ae - pinkish gray; weak, platy

Bt - grayish brown; clay; weak, fine, blocky; very sticky; pH 7.4; gradual, smooth boundary; temperature at 20 cm, 8°C

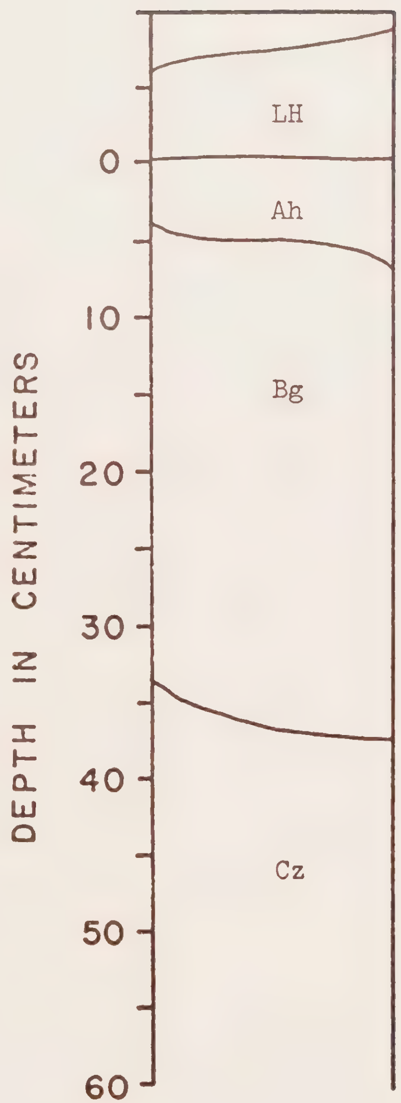
BC - light brownish gray; silty clay; very sticky; pH 4.4

Cca - light brownish gray; clay; pH 4.9; temperature at 50 cm, 5°C

(b) Orthic Humic Gleysol

This poorly-drained member is located mainly in the receiving areas. There is evidence of much mixing of organic and mineral material throughout the section.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m						
<10 m		x				*Picea mariana*, *Larix laricina*, *Betula papyrifera*
Shrubs						
>2 m						
1-2 m	x					*Alnus crispa*
<1 m			x			*Ledum groenlandicum*, *Alnus crispa*, *Potentilla fruticosa*, *Vaccinium uliginosum*, *Arctostaphylos rubra*, *Salix* spp. *Rubus chamaemorus*
Herbs						
Graminoids	x					*Eriophorum spissum*, *Equisetum sylvaticum*, *Carex* spp., *Calamagrostis canadensis*
Sphagna		x				*Sphagnum* spp.
Mosses				x		*Aulacomnium palustre*, *Hylocomium splendens*
Lichens	x					*Cladonia mitis*, *Cladonia rangiferina*, *Cladonia alpestris*



L1; Orthic Humic Gleysol

LH - decomposing organic material

Ah - very dark brown; turfy; medium granular to fine blocky; pH 5.9

Bg - dark reddish brown; weak, course, columnar; pH 5.6; temperature at 20 cm, 3°C; diffuse, gradual boundary

Cz - very dark gray; massive; pH 5.8; temperature at 50 cm, 0°C; (many ice lenses)

(d) Cryic Fibrisol

This soil is found in the slope bog and peat plateau areas intermingled throughout the entire lacustrine plain area. The soil is poorly-drained and is frozen at approximately 35 cm.

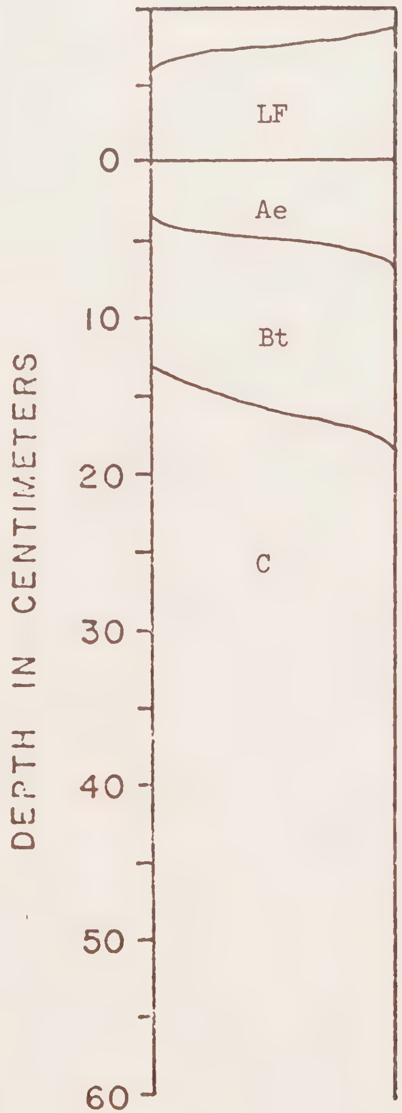
L2; Lacustrine shallow over till

(a) Orthic Gray Luvisol

This landform consists of a clay textured lacustrine capping over glacial till material of approximately the same texture. The soil is imperfectly-drained and the vegetation consist mainly of black spruce, tamarack, various shrubs, herbs, feathermosses and reindeer mosses.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m	x					_Larix laricina_
<10 m				x		_Picea mariana_, _Betula papyrifera_
Shrubs >2 m						
1-2 m		x				_Alnus crispa_, _Salix_ spp.
<1 m					x	_Ledum groenlandicum_, _Vaccinium_ sp., _Rosa_ sp., _Vaccinium vitis-idaea_
Herbs	x					_Comandra livida_
Graminoids		x				_Equisetum scirpoides_
Sphagna						
Mosses			x			_Hylocomium splendens_, _Dicranum undulatum_
Lichens			x			_Cladonia mitis_, _Cladonia rangiferina_, _Peltigera aphthosa_, _Cladonia alpestris_

L2; Orthic Gray Luvisol



LF - decomposing organic material

Ae - light olive brown; silty clay; medium blocky; pH 4.2.

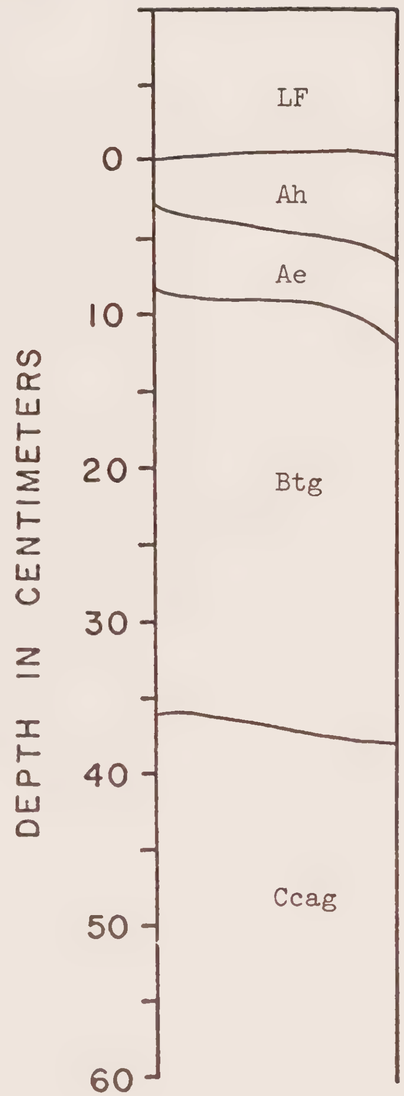
Bt - very dark grayish brown; silty clay; coarse blocky breaking to medium subangular blocky; very sticky; pH 5.4; abrupt, smooth boundary.

C - dark olive gray; clay; sticky; pH 5.9; temperature at 20 cm, 1°C; temperature at 50 cm, o°C.

(b) Humic Eluviated Gleysol

This poorly drained soil is associated with drainageways extending down long slopes. This gives a dark stringer appearance on the mosaic.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m				x		Picea mariana, Betula papyrifera, Larix laricina
Shrubs >2 m						
1-2 m	x					Alnus crispa, Salix spp.
<1 m					x	Alnus crispa, Salix spp., Vaccinium sp., Ledum groenlandicum, Rosa sp. Potentilla fruticosa
Herbs	x					Pyrola secunda, Comandra livida
Graminoids	x					Equisetum scirpoides
Sphagna	x					Sphagnum spp.
Mosses	x					Hylocomium splendens, Campthothecium nitens, Dicranum undulatum
Lichens	x					Cladonia mitis, Cladonia alpestris, Cetraria cuculata



L2; Humic Eluviated Gleysol

LF - decomposing organic material

Ah - dark brown; turfy; pH 5.7

Ae - very dark grayish brown; weak, platy; pH 5.5

Btg - dark reddish brown (5YR 3/2m); clay; fine, subangular blocky; very sticky; pH 5.4; abrupt, smooth boundary; temperature at 20 cm, 3°C

Ccag - dark olive gray; clay; sticky; pH 5.9; temperature at 50 cm, 0°C

(c) Cryic Fibrisol

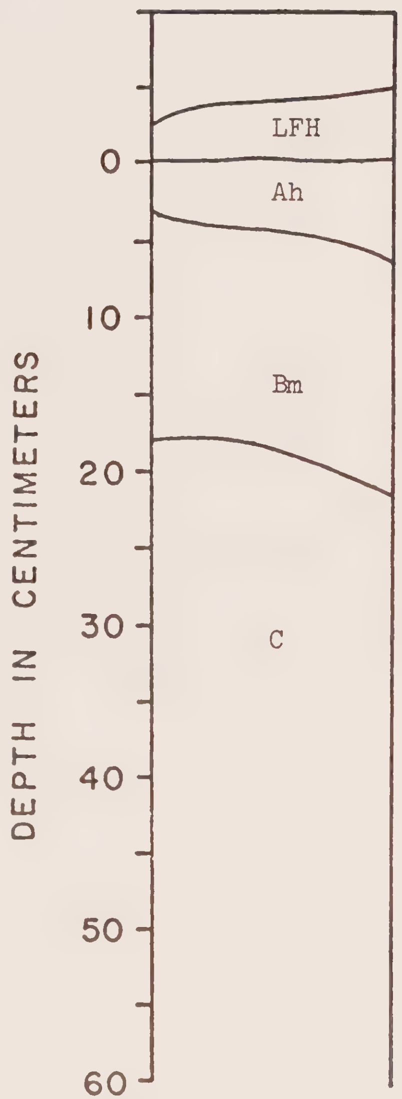
This soil is similar to the L1 - Cryic Fibrisol.

S1; shale bedrock

(a) Lithic Alpine Dystric Brunisol

This moderately well drained soil is developed on the many erosional remnants dominantly composed of shale bedrock, located on the east slope of Cap mountain. The material is a gravelly sandy loam texture and extremely red in color due to the shale bedrock. (Figure 61)

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m						
Shrubs >2 m						
1-2 m						
<1 m				x		Salix spp., Betula glandulosa, Salix reticulata, Rosa spp., Potentilla fruticosa, Vaccinium sp.
Herbs				x		Anemone parviflora, Dryas sp., Pyrola sp., Solidago sp., Arnica sp.,
Graminoids						
Sphagna						
Mosses			x			Campthothecium nitens, Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis
Lichens		x				Cetraria cuculata



S1; Lithic Alpine Dystric Brunisol

LFH - decomposing organic material

Ah - dark reddish gray; medium sand; turfy; pH 6.6

Bm - brown; loamy sand; single grained, structureless; non-sticky; gradual, wavy boundary; pH 4.0

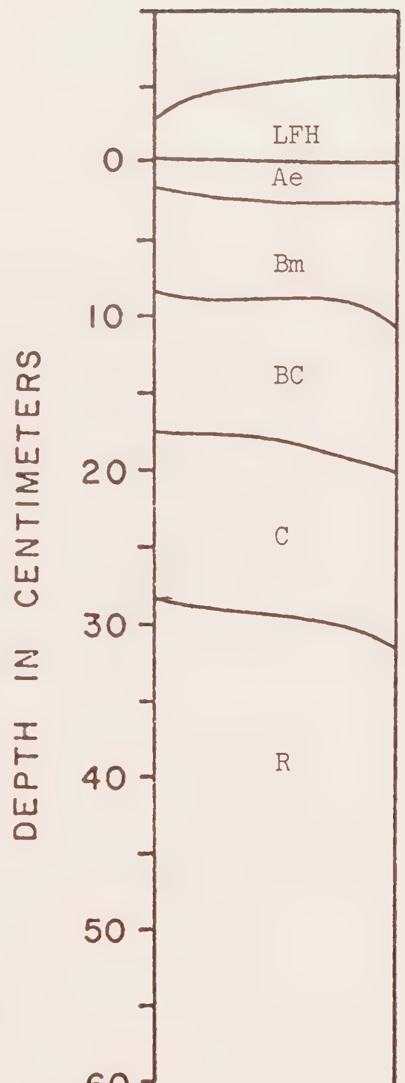
C - weak red; sandy loam; single grained, structureless; pH 3.9

Q1; Quartzite and sandstone bedrock

(a) Lithic Degraded Dystric Brunisol

This soil is typical of the Felsenmeer area composed of many large shattered blocks of rock in Cap Mountain. The soil is of a gravelly loamy sand texture and is moderately well-drained (Figure 62).

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m						
Shrubs >2 m						
1-2 m						
<1 m			x			<u>Betula glandulosa</u>, <u>Ledum groenlandicum</u>, <u>Empetrum nigrum</u>, <u>Vaccinium vitis-idaea</u>
Herbs						
Graminoids						
Sphagna						
Mosses						
Lichens	x					<u>Cladonia alpestris</u>, <u>Cladonia mitis</u>



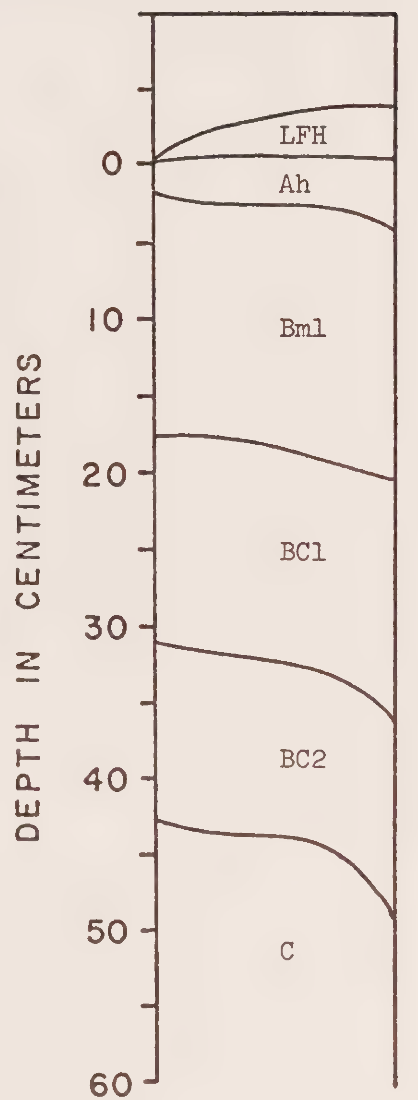
Q1; Lithic Degraded Dystric Brunisol

LFH	-	decomposing organic material
Ae	-	light brownish gray; loamy sand; single grained, structureless; pH 3.4
Bm	-	dark reddish brown; loam; weak subangular blocky; slightly sticky; pH 4.1; gradual, wavy boundary
BC	-	reddish brown; sandy loam; single grained, structureless; pH 4.1
C	-	dark grayish brown; gravelly loamy sand; single grained; structureless; pH 4.1
R	-	bedrock

(b) Alpine Eutric Brunisol

This moderately well-drained soil is developed in areas of deeper soil accumulation. Depth to bedrock is approximately 60 to 100 cm.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m						
Shrubs >2 m						
1-2 m						
<1 m			x			*Betula glandulosa*, *Ledum groenlandicum*, *Empetrum nigrum*, *Vaccinium vitis-idaea*
Herbs		x				*Drosera rotundifolia*
Graminoids						
Sphagna						
Mosses		x				*Cladonia mitis*, *Peltigera aphthosa*
Lichens						



Q1; Alpine Eutric Brunisol

LFH - decomposing organic material

Ah - dark reddish brown; turfy; sandy clay; pH 5.2

Bml - brown; loam; weak, subangular blocky; slightly sticky; pH 6.3; diffuse, irregular boundary

BC1 - grayish brown; clay loam; very coarse, subangular blocky; slightly sticky; pH 5.6; diffuse, irregular boundary

BC2 - grayish brown; clay loam; fine subangular blocky; sticky; pH 5.9; diffuse irregular boundary

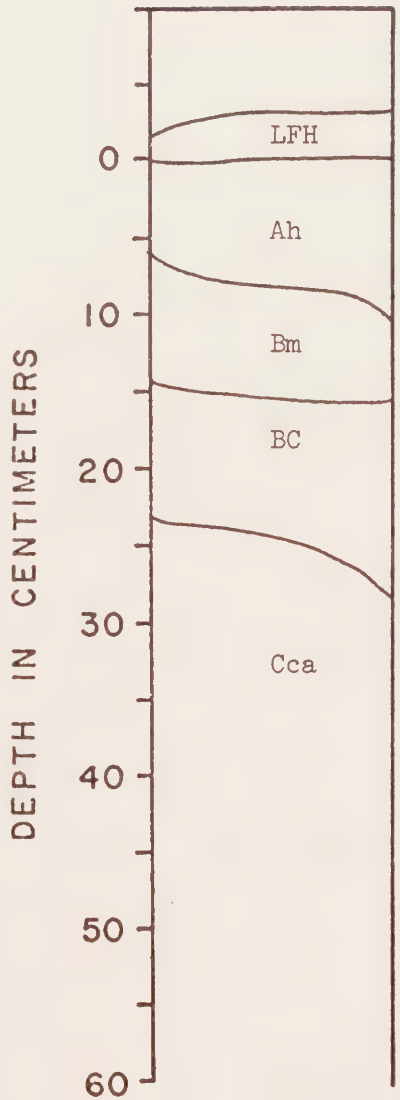
C - dark brown; clay loam; sticky; pH 6.8

D1; Dolomites, Limestone and Calcareous shales

(a) Alpine Eutric Brunisol

This soil is of a gravelly loam texture and is the dominant soil in the limestone and dolomite areas north of Cap Mountain and in the Canyon Range in the Dahadinni area. The soil is moderately well-drained.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m	x					Picea glauca (krummholz)
Shrubs >2 m						
1-2 m						
<1 m		x				Betula glandulosa, Vaccinium sp., Salix reticulata
Herbs				x		Dryas sp., Hedysarum alpinum, Anemone parviflora, Pedicularis sp.
Graminoids		x				Eriophorum sp., Carex spp.
Sphagna						
Mosses	x					Hylocomium splendens
Lichens				x		Cetraria cuculata



D1; Alpine Eutric Brunisol

LFH - decomposing organic material

Ah - dark brown; loam; turfy; pH 6.6

Bm - brown; silt loam to clay loam; fine subangular blocky; slightly sticky; pH 6.7; diffuse, wavy boundary

BC - yellowish brown; gravelly loam; single grained, structureless; pH 6.8; temperature at 20 cm, 8°C

Cca - light brownish gray; gravelly loam; single grained, structureless; pH 7.0; temperature at 50 cm, 6°C

O; Organic

O1; Fen

(a) Fenno Fibrisol

These soils are derived from sedge peat. They are very poorly-drained and are the dominant soils in this organic landform that is influenced by minerotrophic ground waters (Figure 63). The depth to frozen ground is variable, with some areas having no ice at all.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m						
<10 m	x					*Picea mariana*
Shrubs						
>2 m						
1-2 m	x					*Betula glandulosa*, *Salix* spp.
<1 m		x				*Chamaedaphne calyculata*, *Myrica gale*, *Ledum decumbens*, *Ledum groenlandicum*
Herbs			x			*Drosera rotundifolia*
Graminoids						
Sphagna						*Sphagnum* spp.
Mosses						
Lichens						

02; Peat plateau

(a) Cryic Fibrisol

These are poorly-drained soils derived from sphagnum peat (Figure 64). The depth of organic buildup is unknown as frozen ground was encountered at shallow depths. The landscape is generally hummocky with many thaw pockets.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees						
>20 m						
10-20 m						
<10 m		x				Picea mariana, Larix laricina
Shrubs						
>2 m						
1-2 m	x					Alnus crispa
<1 m					x	Ledum groenlandicum, Salix spp., Vaccinium sp. Andromeda polifolia, Rosa acicularis, Potentilla fruticosa
Herbs				x		Comandra livida, Cornus canadensis, Pedicularis sp.
Graminoids	x					Equisetum scirpoides
Sphagna		x				Sphagnum fuscum
Mosses		x				Dicranum undulatum, Camphthothecium nitens
Lichens				x		Cladonia mitis, Cladonia rangiferina, Cetraria cuculata

(b) Cryic Mesisol

These very poorly-drained soils are usually found in depressions between the peat plateaux. Depth to ice is normally 45 cm. or deeper.

03; Polygonal bog

(a) Cryic Fibrisol

These soils are developed under lichen peat deposits and are considered poorly-drained. They have a moderately decomposed organic layer over undecomposed organic peat deposits. There is a polygonal pattern of cracks or melts in the bog.

Vegetation Strata and Cover	1-5%	5-25%	25-50%	50-75%	75-100%	Species Composition and Remarks
Trees >20 m						
10-20 m						
<10 m						
Shrubs >2 m						
1-2 m						
<1 m			x			Betula glandulosa; Ledum decumbens, Andromeda polifolia, Vaccinium vitis-idaea, Rubus chamaemorus
Herbs						
Graminoids						
Sphagna	x					Sphagnum fuscum
Mosses						
Lichens					x	Cladonia alpestris, Cetraria cuculata, Cladonia rangiferina, Cladonia mitis

APPENDIX 12.3 SOME SELECTED CHEMICAL AND PHYSICAL PROPERTIES OF THE SOILS

SOIL	HORIZON	DEPTH (cm)	TEXTURE %S	%Si	%C	CLASS	pH H_2O	$CaCl_2$	O.M. %	N %	C/N %	OXALATE EXTRACTABLE Fe %	Al %	C.E.C. me/100gms	EXCHANGEABLE CATION Na me/100gms	K	Mg	Ca	WATER RETENTION 1/10 BAR %	15 BAR %
Alluvium; alluvial terrace or plain																				
Degraded	LFH	5-0					6.2	5.9	38.0	0.38	58			68.21	9.06	1.53	5.31	50.00		
Dystric Brunisol	Ae	0-3	39.2	51.4	9.4	sil	6.6	6.5	4.4	0.05	51			11.47	4.13	0.12	1.50	13.75	8.5	4.0
	Bm	3-10	53.3	30.3	16.4	l	6.6	5.7	1.1	0.03	21	0.28	0.13	8.80	1.75	0.09	1.81	81.25	32.6	5.9
	BC	10-18	55.3	27.4	17.3	Sl	7.4	7.0	1.7	0.03	33	0.24	0.16	12.62	1.75	0.11	2.75	15.00	23.8	7.9
	C	18+	43.4	32.4	24.2	l	8.2	7.6	0.8	0.07	7			9.82	1.69	0.02	3.00	42.50	22.60	60.8
Peaty Rego	L	30-25																		
Humic Gleysol	F	25-12					7.0	6.6	66.7	1.09	36			183.75	0.15	0.84	26.56	125.00		
	H	12-0					6.9	6.1	42.4	1.01	24			232.25	0.12	0.14	19.63	121.25	177.3	67.9
	Ah	0-10	42.5	40.3	17.2	l	6.9	6.2	17.8	0.34	30			72.25	0.04	0.17	9.75	58.75	82.4	26.3
	Cgz	10+	36.5	45.3	18.2	l	7.1	6.4	1.5	0.19	4	0.7	0.13	24.75	0.02	0.19	5.44	21.25		11.6
Alluvium; floodplain																				
Cumulic	LF	8-0					5.3	4.7	67.7	1.10	36			121.25	0.50	1.69	15.62	2.75		
Regosol	Ah	0-8	19.1	50.6	30.3	Sicl	6.7	6.2	17.3	0.23	43			60.00	0.11	0.25	11.94	41.25	92.7	27.2
	C1	8-20	26.0	46.3	27.7	Cl	7.0	6.2	5.6	0.18	18	0.60	0.16	26.62	0.10	0.20	5.56	23.75	46.9	14.2
	C2	20+	25.5	50.1	24.4	Sil	6.9	6.4	5.5	0.14	22	1.20	0.17	52.75	0.19	0.35	9.62	1.80	76.9	21.0
Colluvium; colluvial fan																				
Orthic	LFH	5-0					6.6	5.9	65.2	2.13	18			158.74	0.10	1.06	30.94	4.13		
Gleysol	Bg	0-13	70.2	20.8	9.0	Sl	6.9	6.4	5.9	0.16	21	0.34	0.14	22.31	0.03	0.17	7.06	17.50	34.8	9.5
	BC	13-23	80.0	18.4	1.6	lS	7.2	6.6	1.7	0.04	24	0.12	0.08	7.90	0.02	0.15	4.00	62.50	16.2	15.3
	C	23+	82.2	15.1	2.7	lS	7.3	6.4	0.7	0.04	10	0.20	0.08	8.03	0.02	0.14	3.75	62.50	11.5	3.7
Peaty Orthic																				
Gleysol	LF	25-20					7.2	6.8	67.9	1.46	27			152.36	0.29	1.87	34.69	4.25		
	H	20-0					6.4	5.8	71.5	1.57	26			163.84	0.13	0.65	32.50	4.75		
	Bg	0-23	70.2	20.8	9.0	Sl	7.2	6.6	5.9	0.16	21	0.34	0.14	22.31	0.03	0.17	7.06	17.50	34.8	9.5
	C	23+	82.2	15.1	2.7	lS	7.3	6.4	1.7	0.04	24	0.20	0.08	8.03	0.02	0.14	3.75	62.50	11.5	8.03
Colluvium; colluvial plain																				
Alpine Eutric	Ah	0-5	50.5	38.6	10.9	l	7.5	7.0	10.1	0.16	37			10.71	0.02	0.18	4.88	0.55		
Brunisol	Bm	5-20	73.8	23.0	3.2	lS	7.8	7.1	10.1	0.14	41			2.80	0.03	0.08	2.75	0.70		
	C	20+	57.9	33.1	9.0	Sl	7.7	7.2	0.3	0.08	3	0.30	0.07	6.50	0.02	0.09	3.13	18.75	19.9	1.3
Peaty Orthic	LF	25-15					6.6	6.2	56.8	1.50	22			100.10	0.11	0.89	21.88	2.75		
Humic Gleysol	H	15-0					5.8	5.6	51.2	1.71	17			110.29	0.10	0.28	20.62	2.75		
	Ah	0-12	37.5	34.1	28.4	Cl	6.9	6.4	25.4	0.67	22			61.45	0.04	0.14	15.25	1.80		
	Bg	12-30	34.2	36.6	29.2	Cl	7.4	6.8	3.2	0.09	20	0.37	0.13	15.43	0.02	0.20	7.38	13.13	24.4	9.9
	C	30+	44.6	27.8	27.6	Cl	7.4	6.6	1.7	0.08	12	0.17	0.14	15.30	0.02	0.20	7.75	13.13	25.7	10.4

SOIL	HORIZON	DEPTH (cm)	TEXTURE %S	%Si	%C	CLASS	pH H_2O	$CaCl_2$	O.M. %	N %	C/N %	OXALATE EXTRACTABLE Fe %	Al %	C.E.C. me/100gms	EXCHANGEABLE CATION Na	K	Mg	Ca	WATER RETENTION 1/10 BAR %	15 BAR %
															me/100gms					
Glacial Till; till plain																				
Degraded	LFH	8-0					3.7	3.0		0.75				104.55	8.44	2.21	2.15	15.63	143.8	98.0
Dystric Brunisol	Ae	0-2																		
	Bm	2-8	21.7	63.4	14.9	Sil	4.7	4.0	2.6	0.07	21	0.72	0.24	16.95	1.69	0.12	1.19	6.25	33.8	9.3
	BC	8-25	32.3	47.8	19.9	l	5.0	4.2	1.7	0.06	16	0.65	1.31	16.70	1.75	0.17	[illegible]	5.63	25.4	14.5
	C	25+	29.5	50.2	20.3	l-Sil	5.3	4.6	1.2	0.05	13	0.42	0.28	15.55	1.69	0.11	3.69	10.00	22.5	9.0
Peaty Rego	LF	28-18					7.2	6.7	61.8	1.29	28			199.54	8.44	0.09	42.50	153.13	298.8	92.0
Humic Gleysol	H	18-0					6.5	6.0	31.2	0.46	39			131.07	3.25	0.17	18.88	87.50	88.6	36.6
	Ah	0-10	70.1	17.4	12.5	Sl	6.9	6.2	6.4	0.22	17			33.79	1.56	0.17	6.69	29.38	32.6	18.8
	Cg	10+	54.3	32.5	13.2	Sl	8.0	7.1	0.1	0.02	3			7.52	1.63	0.11	4.50	10.00	17.7	5.6
Glacial Till; drumlinized till plain																				
Degraded	LFH	8-0							18.5	0.16	67			32.51	1.63	0.40	1.00	3.75		
Dystric Brunisol	Ae	0-4					4.4	3.7	1.3	0.02	38			5.10	1.63	0.07	0.14	3.00	18.6	2.8
	Bm	4-15	50.2	26.2	23.3	SCl	5.5	4.5	0.6	0.03	12	0.24	0.30	14.79	1.63	0.17	1.88	2.28	32.1	7.1
	BC	15-20	57.3	35.0	17.7	Sl	6.3	5.3	0.7	0.02	20	0.27	0.19	10.96	1.70	0.13	3.56	6.88	22.5	7.4
	C	20+	51.1	34.0	14.9	l	7.7	7.2	1.0	0.03	19	0.43	0.14	7.01	1.69	0.17	3.56	13.13	20.0	5.2
Peaty Orthic	LFH	8-0					5.9	5.3	68.9	0.35	114			184.87	1.15	1.29	24.69	4.00		
Humic Gleysol	Ah	0-8	55.8	26.3	17.9	Sl	6.5	5.8	9.5	0.28	20			43.86	0.43	0.12	10.38	1.40	49.4	14.9
	Bg	8-15	55.2	32.3	12.5	Sl	6.9	6.2	1.7	0.07	14	0.50	0.18	16.57	0.24	0.17	6.13	14.38	25.1	7.9
	Cg	15+	43.7	42.4	13.9	l	7.4	6.8	0.9	0.03	17	0.40	0.09	6.25	0.51	0.68	27.50	3.38	19.4	7.2
Glacial Till; eroded till plain																				
Degraded	LFH	2-0					4.3	3.7	38.4	0.44	51			72.67	8.13	1.44	2.38	9.38	83.2	36.8
Eutric Brunisol	Ae	0-2	59.2	36.6	2.2	Sl	4.0	3.7	4.2	0.07	35			9.43	1.50	0.09	2.65	1.73	22.7	5.8
	Bml	2-12	33.9	28.2	17.9	Sl	5.4	4.7	1.2	0.03	23	0.24	0.18	11.86	1.75	0.18	2.38	5.00	33.4	6.0
	BmZ	12-20	41.2	25.3	33.5	Cl	7.2	6.6	1.5	0.05	17	0.29	0.20	20.78	1.75	0.23	7.44	13.75	28.5	11.5
	Cca	20+	55.5	27.8	16.7	Sl	7.9	7.1	0.4	0.05	5	0.31	0.09	10.07	1.75	0.11	5.13	10.63	21.9	6.2
Glacial Till; till complex																				
Degraded	LFH	15-0					3.5	3.0	43.0	0.58	43			78.54	3.50	0.92	2.50	3.95		
Dystric Brunisol	Ae	0-2	17.5	47.7	34.8					0.00				49.10	1.75	0.35	2.06	3.15		
	Bm	2-14	15.6	67.0	17.4	Sil	4.8	3.9	1.4	0.06	13	0.60	0.29	13.51	1.94	0.11	1.25	2.10	27.4	8.6
	BC	14-30	12.2	58.1	29.7	SiCl	4.9	4.2	2.3	0.08	16	0.62	0.38	20.27	1.75	0.34	2.13	3.25	33.4	13.9
	C	30+	47.1	35.8	17.1	l	5.2	4.2	0.8	0.03	15	0.31	0.24	14.41	1.76	0.12	2.60	34.46	16.7	7.8
Peaty Rego	Of	28-10					6.6	5.9	17.0	1.11	9			161.93	0.21	0.86	32.81	3.88		
Humic Gleysol	Om	10-0					5.9	5.3	21.7	0.52	24			65.02	0.05	0.10	10.06	41.25	68.6	26.4
	Ah	0-5	67.5	21.2	11.3	Sl	6.1	5.2	7.7	0.19	23			31.87	0.03	0.17	5.69	23.75	33.5	11.7
	Cgz	5+	64.0	25.7	10.3	Sl	6.2	5.3	0.6	0.11	3	0.45	0.11	17.85	0.03	0.12	3.50	16.25	36.1	8.1

SOIL	HORIZON	DEPTH (cm)	TEXTURE %S	%Si	%C	CLASS	pH H_2O	$CaCl_2$	O.M. %	N %	C/N	OXALATE EXTRACTABLE Fe %	Al %	C.E.C. me/100gms	EXCHANG[EABLE] Na
Glacial Outwash; kames and esker segments															
Degraded Eutric Brunisol	LFH	3-0													
	Ae	0-6					4.2	3.5	0.9	0.02	26			4.72	0.02
	Bm	6-37					5.0	4.2	0.6	0.02	17	0.34	0.28	8.16	0.01
	Cca	37+					6.7	6.4	0.3	0.06	3	0.25	0.07	1.27	0.01
Degraded Eutric Brunisol	LF	3-0													
	Ae	0-5	44.2	41.0	14.8	l	6.2	5.4	2.0	0.05	23			11.35	0.38
	Bm	5-12	23.0	29.5	47.5	C	6.6	5.8	1.7	0.05	20	0.20	0.21	23.08	0.39
	BC	12-25	32.9	37.8	29.3	Cl	7.9	7.3	0.5	0.10	3	0.40	0.12	16.87	0.10
	Cca	25+	43.1	38.1	18.8	l	8.1	7.3	0.3	0.03	6	0.40	0.08	8.00	0.38
Gleyed Degraded Eutric Brunisol	LFH	20-0													
	Ae	0-2	60.5	32.4	7.0	Sl	3.8	3.2	3.3	0.07	27			11.47	0.03
	Bmg	2-22	48.2	33.3	18.5	l	4.6	3.9	1.8	0.06	17	0.51	0.22	15.55	0.03
	BC	22+					6.7	6.3	0.6	0.01	34	0.23	0.06	1.40	0.01
	Cgz														
Glacial Outwash; esker and esker complex															
Othic Eutric Brunisol	LFH	4-0													
	Bm	0-15	66.0	23.5	10.5	Sl	6.4	5.9	1.9	0.05	22	0.36	0.12	13.13	0.12
	BC	15-40					7.9	7.2	0.6	0.02	17	0.30	0.09	12.62	0.02
	C	40+					7.8	7.0	0.4	0.00		0.20	0.04	0.38	0.02
Lacustrine; Lacustrine plain															
Orthic Gray Luvisol	LFH	3-0													
	Ae	0-2													
	B+	2-8					7.8	7.4	4.7	0.08	34	0.42	0.14	31.24	1.75
	BC	8-37	1.5	58.5	40.0	Sic	5.2	4.4	1.5	0.07	12	0.70	0.25	22.76	1.56
	Cca	37+					5.4	4.9	0.9	0.05	10	0.46	0.18	27.16	1.69
Orthic Humic Gleysol	LFH	8-0					4.6	4.1	77.2	1.42	32			147.50	0.08
	Ah	0-5					6.5	5.9	32.9	0.80	24			128.25	0.05
	Bg	5-37					6.2	5.6	0.8	0.82	1	0.90	0.36	123.25	0.05
	Cgz	37+					6.3	5.8	0.4	0.82	1	0.90	0.34	142.25	0.06
Lacustrine; Lacustrine shallow over till															
Othic Gray Luvisol	LF	8-0					4.1	3.5	54.3	0.92	34			111.87	0.45
	Ae	0-5	3.1	53.7	43.2	Sic	4.8	4.2	4.4	0.14	18			26.50	0.11
	B+	5-15	1.2	47.2	51.6	Sic	6.2	5.4	3.1	0.14	13	0.30	0.23	25.75	0.11
	C	15+	7.0	22.4	70.6	C	6.6	5.9	1.9	0.08	14	0.30	0.22	30.50	0.12

SOIL	HORIZON	DEPTH (cm)	TEXTURE %S	%Si	%C	CLASS	pH H_2O	pH $CaCl_2$	O.M. %	N %	C/N %	OXALATE EXTRACTABLE Fe %	Al %	C.E.C. me/100gms	EXCHANGEABLE CATION me/100gms Na	K	Mg	Ca	WATER RETENTION 1/10 BAR %	15 BAR %
Bedrock; shales																				
Lithic Alpine Dystric Brunisol	Ah	0-5	94.4	2.8	2.8	S	5.2	4.3	6.7	0.07	56			8.16	0.01	0.25	2.00	2.03	9.4	5.4
	Bm	5-22	79.2	11.2	9.6	lS	4.7	4.0	3.1	0.09	20	0.13	0.12	10.34	0.02	0.22	1.75	1.38	19.6	8.6
	C	22+	70.3	16.1	13.5	Sl	4.7	3.9	0.8	0.09	5	0.22	0.13	10.58	0.02	0.19	1.75	1.45	17.7	7.8
Bedrock; quartzite and sandstone																				
Lithic Degraded Dystric Brunisol	LFH	5-0					3.9	3.3	31.1	0.54	33			36.97	3.62	0.65	2.91	3.65	50.1	30.9
	Ae	0-2	78.7	11.2	10.1	Sl	4.0	3.4	1.6	0.03	31			3.82	1.94	0.05	0.15	0.45	11.2	2.5
	Bm	2-10	49.6	30.7	19.7	l	5.0	4.1	0.8	0.03	15	0.16	0.23	7.39	1.75	0.12	0.27	0.35	19.5	6.7
	BC	10-20	63.5	24.1	12.4	Sl	4.9	4.1	0.5	0.02	14	0.13	0.24	9.05	1.75	0.09	0.40	0.48	15.4	4.4
	C	20+	77.6	16.3	6.1	lS	5.0	4.1	0.4	0.01	23	0.07	0.12	3.95	1.75	0.04	0.16	0.25	10.8	2.2
Alpine Eutric Brunisol	Ah	0-2	44.4	15.2	40.4	SC	5.6	5.1	14.4	0.46.	18			40.16	8.75	0.34	6.88	12.88	47.9	22.3
	Bm1	2-20	39.0	32.4	28.6	Cl	6.6	6.3	3.4	0.14	14	0.20	0.20	19.89	0.63	0.29	6.06	5.00	52.0	11.3
	Bm2	20-34	32.4	27.3	40.3	C	6.2	5.6	1.9	0.08	14	0.19	0.19	17.47	0.69	0.24	6.44	13.3	26.2	9.9
	Bm3	34-45	29.2	29.8	41.0	Cl	6.5	5.9	1.9	0.09	12	0.17	0.18	19.25	0.69	0.22	7.88	15.00	32.0	13.6
	C	45+	33.2	30.9	35.9	Cl	7.3	6.8	0.8	0.08	6	0.19	0.14	15.17	0.63	0.18	8.06	15.00	11.9	15.17
Bedrock; dolomites, limestsones and calcareous shales																				
Alpine Eutric Brunisol	Ah	0-10	37.9	45.5	16.6	l	6.8	6.6	13.9	0.27	30			49.10	0.03	0.18	13.63	33.75	59.7	19.8
	Bm	10-15	23.6	49.0	27.3	l-Sil	7.4	6.6	3.4	0.10	19	0.27	0.18	18.99	0.02	0.17	7.94	16.88	105.3	9.9
	Bc	15-28	49.7	42.8	7.5	l-Sl	7.6	6.8	0.8	0.04	12	0.21	0.07	6.12	0.02	0.10	3.50	20.63	18.5	3.9
	Cca	28+	42.7	47.4	9.9	l	7.8	7.0	0.6	0.03	11	0.18	0.06	5.23	0.03	0.10	3.19	28.13	17.5	4.6
Organic; fen																				
Fenno Fibrisol	Of1	0-15					3.9	3.0	67.5	0.68	58			126.22	1.96	1.55	8.13	0.88		
	Of2	15-25					5.1	4.3	43.0	1.78	14			99.45	1.89	0.38	8.44	1.50		
	Of3	25+					5.1	4.4	46.9	1.72	16			82.87	1.95	0.29	7.81	1.25		
Organic; peat plateau																				
Cryic Fibrisol	Of1	0-20					3.4	2.6	72.9	0.71	60			34.42	0.04	0.08	0.81	4.38		
	Of2	20-35					3.4	2.5	70.4	0.82	50			156.82	0.15	0.28	3.75	1.25		
	Ofz	35+																		

Figure 3. Alluvial terraces adjacent to Mackenzie River.

Figure 4. Alluvial floodplain adjacent to small river.

Figure 5. Colluvial fan area east of Cap Mountain.

Figure 6. Colluvium and bedrock dissected by water channels.

Figure 7. Poorly drained soils in glacial till area.

Figure 8. Drumlinized till plain.

Figure 9. Organic soils in matrix of drumlinized till.

Figure 10. Moderately will drained soils in matrix of poorly drained members.

Figure 11. Pock-marked topography of eroded till plain area.

Figure 12. Shallow till over bedrock in Dahadinni area.

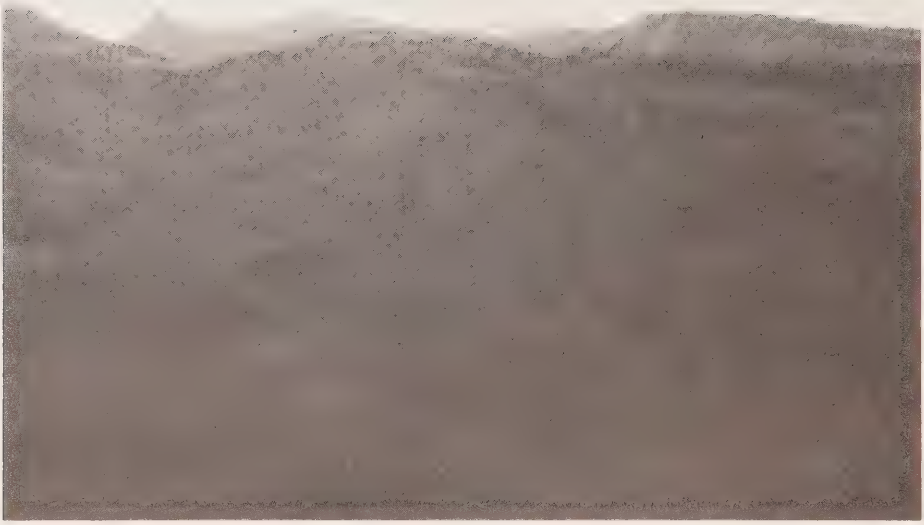


Figure 13. Complex of till, colluvium and alluvium in alpine and sub-alpine valleys.

Figure 14. Outwash deposits consisting of kame and esker segments.

Figure 15. Outwash deposits of esker and esker complexes.

Figure 16. Thaw depressions and peat plateau within the matrix of glacial outwash.

Figure 17. Lacustrine deposits adjacent to the alluvial deposits fo the Mackenzie River.

Figure 18. Lacustrine capping over fine textured glacial till.

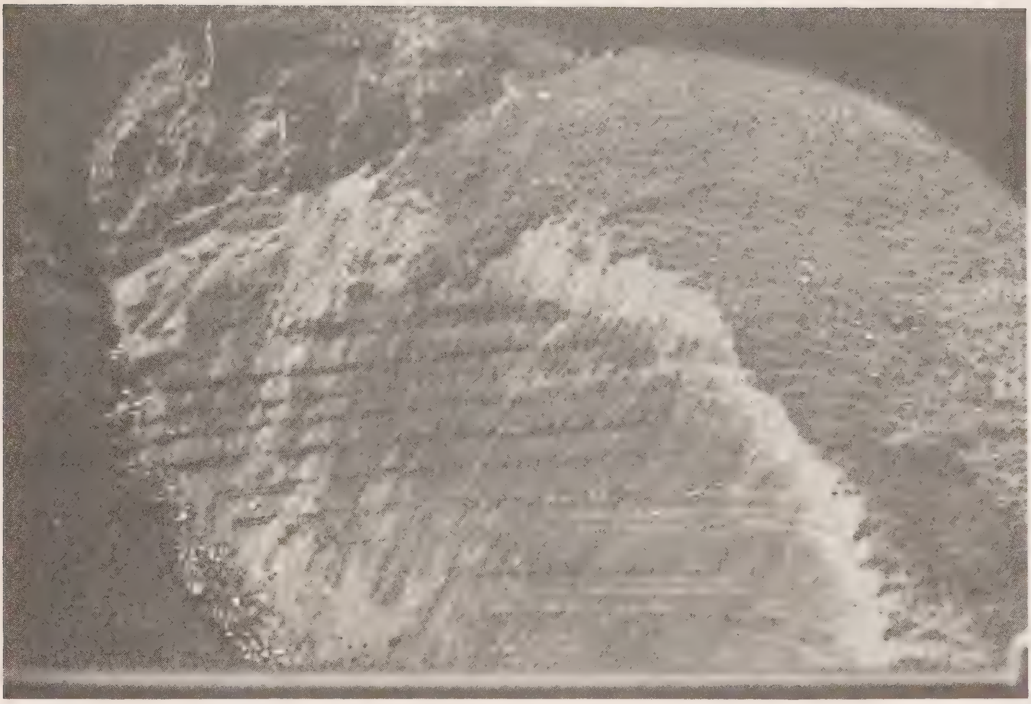


Figure 19. Shale bedrock; east slope of Cap Mountain.

Figure 20. Vegetation on shale bedrock.

Figure 21. Felsenmeer landscape; shattered blocks of quartizite and sandstone.

Figure 22. Alpine Eutric Brunisol developed on quartizite bedrock.

Figure 23. Stone stripes and stone rings on Cap Mountain

Figure 24. Accumulation of organic material in alpine meadow.

Figure 25. Shallow material over calcareous shale bedrock, Canyon Range.

Figure 26. Fen; located in many areas throughout the study strip.

Figure 27. Peat plateau derived from sphagnum peat.

Figure 28. Hummocky and irregular surface of peat plateau surrounding minerotrophic fen deposits.

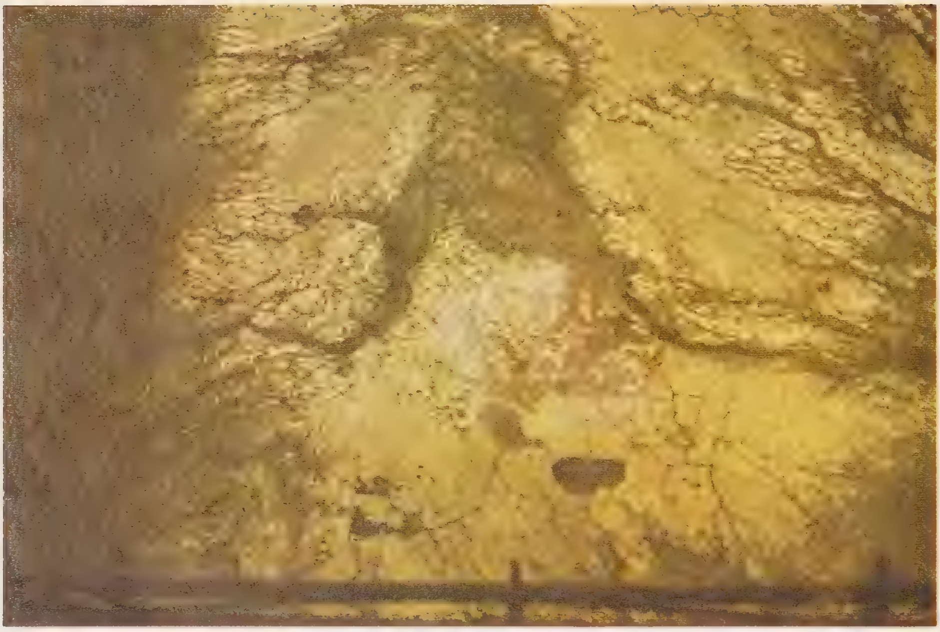


Figure 29. Polygonal bog area; note the cracks in the large lichen covered bogs.

Figure 30. East Face of Cap Mountain

Figure 31. Stone stripe area, Cap Mountain

Figure 32. Rocky area, Cap Mountain

Figure 33. Meadow area, Cap Mountain

Figure 34. Stone Stripes

Figure 35. Coalescing fans at base of Cap Mountain

Figure 36. Vegetation of coalescing fan area.

Figure 37. Seismic line on peat plateau near Lily Pad Lake.

Figure 38. Bare peat and invading vegetation species on seismic line near Lily Pad Lake, Wrigley area, N.W.T.

Figure 41. Seismic line on peat plateau near the south arm of the Ochre River.

Figure 42. Undisturbed natural vegetation of seismic line near the south arm of the Ochre River.

Figure 44. Typical undisturbed vegetation of peat plateau crossed by winter road.

Figure 45. Winter road across peat plateau showing depressions and begetative regeneration.

Figure 46. Stream flowing down seismic line.

Figure 47. Soil erosion caused by stream flowing down seismic line which intersected natural drainage channels, Wrigley area, N.W.T.

Figure 48. Ruts formed in seismic line as a result of summer use by all-terrain vehicle.

Figure 49. Pools of standing water in ruts of seismic line used as a summer road.

Figure 51. Trench on peat plateau of Horn Plateau dug in 1971.

Figure 52. Ice contact in polygonal bog of Horn Plateau (1971).

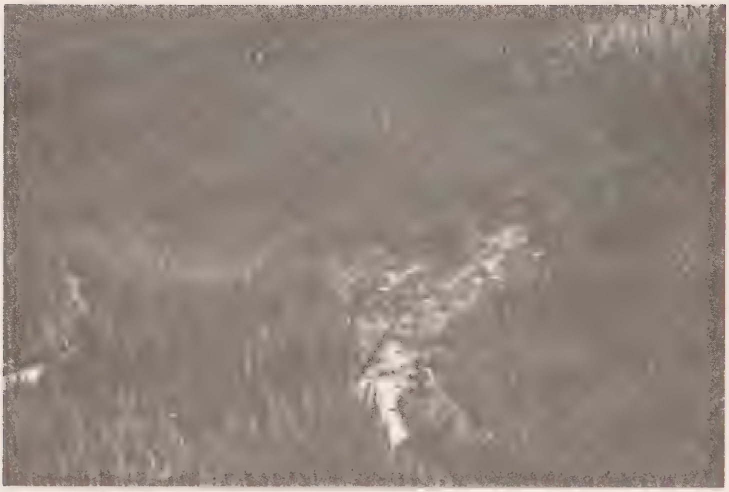


Figure 54. River bank slump on minor stream flowing into Mackenzie River.

Figure 55. Relatively pure stands of birch on alluvial material.

Figure 56. Cumulic Regosol on alluvial material of small creek floodplains.

Figure 57. Peaty Orthic Gleysol on poorly drained alluvial material

Figure 58. Moderately well drained Degraded Dystric Brunisol developed from till material.

Figure 59. Orthic Humic Gleysol developed from drunlinized till in receiving areas.

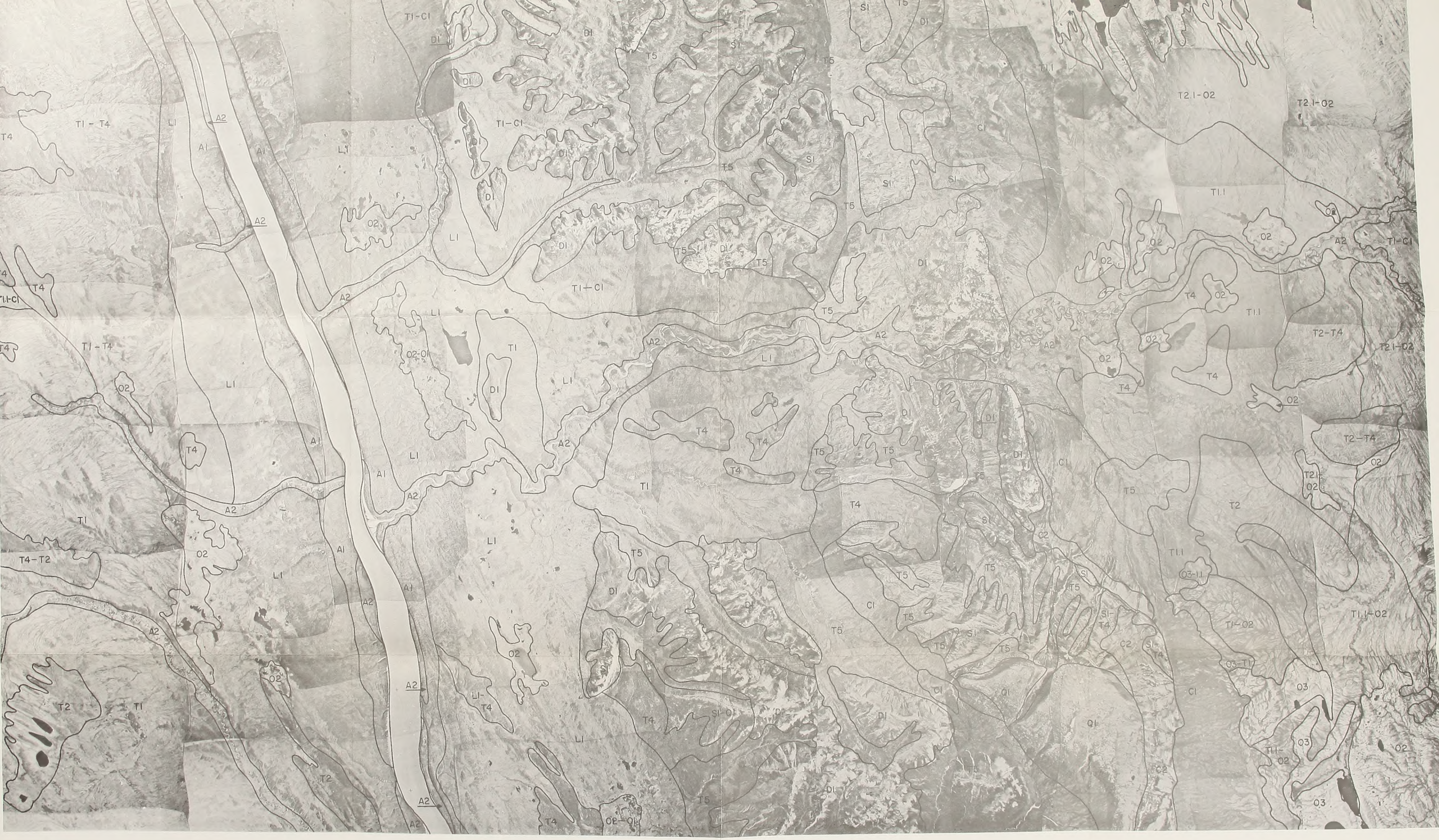
Figure 60. Orthic Gray Luvisol developed on imperfectly drained lacustrine material.

Figure 61. Soil developed from shale bedrock.

Figure 62. Lithic Degraded Dystric Brunisol developed on quartzite bedrock area, Cap Mountain.

Figure 63. Fen-type material (soils derived from sedge-type peat).

Figure 64. Sphagnum peat comprising peat plateau material.



WRIGLEY AREA NO. I.

MG-937 - 1

DATE FLOWN 1950 &51

SEMICONTROLLED MOSAIC

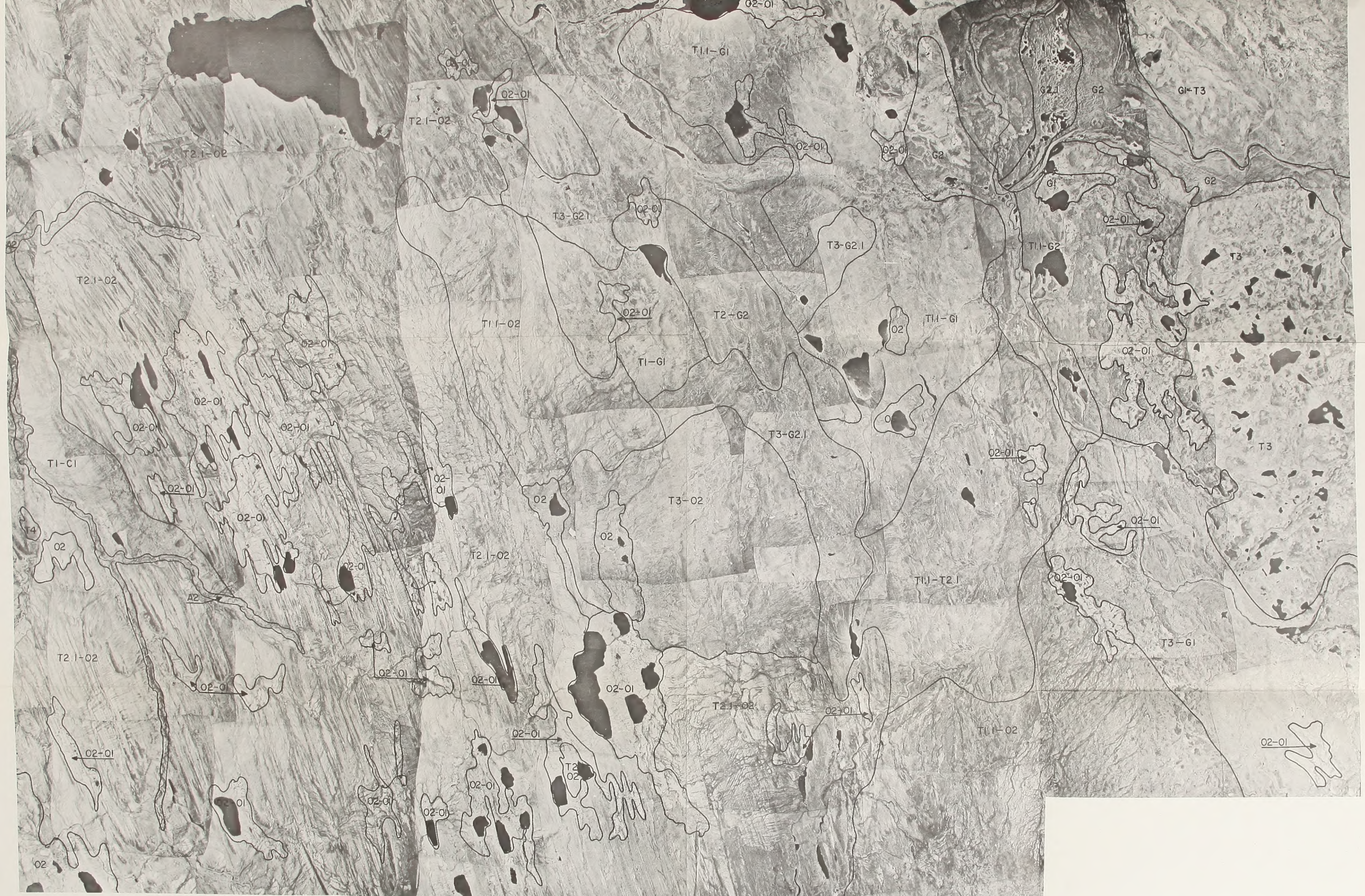
N.A.P.L. REPRODUCTION CENTRE

A.12579,-A.12607, A.12609, A.12610, A.12692,

A.12700, A.12701, A.13045, A.13214, A.13290.

MAP SHEET 95-O

ENERGY, MINES & RESOURCES



WRIGLEY AREA NO. 2.

MG-937 - 2
DATE FLOWN 1950 &51
SEMICONTROLLED MOSAIC
N.A.P.L. REPRODUCTION CENTRE

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A.12700, A.12701, A.13045, A.13214, A.13290.
MAP SHEET 95-O
ENERGY, MINES & RESOURCES

DAHADINNI, N.W.T.

MG-951

DATE FLOWN 1961, 1964.

SEMICONTROLLED MOSAIC

N.A.P.L. REPRODUCTION CENTRE

A.17122,A.18310& A.18308

MAP SHEET, 95N-7,8,9&10.

ENERGY, MINES & RESOURCES.